ARTIFICIAL MANURES.

HOW TO MAKE, BUY, VALUE, AND USE.

A HANDBOOK FOR

Agriculturists, Chemical Manure Manufacturers and Merchants, Gardeners, and others concerned in similar pursuits.

By ALFRED SIBSON, F.C.S.,

Consulting and Analytical Chemist.

Author of "Agricultural Chemistry," "Every-day Chemistry," "Food, Feeding, and Manure," "A Lecture on Superphosphate," etc. Late (for eight years) Assistant Professor of Chemistry in the Royal Agricultural College, Cirencester, and First Assistant in Dr. Voelcker's Private Laboratory. Formerly Student of the Royal College of Chemistry, and the Birkbeck Laboratory of University College.

Revised and Re-written by the Author and

A. E. SIBSON, F.C.S.

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LATE (FOR EIGHT YEARS) ASSISTANT PROFESSOR OF CHEMISTRY IN THE ROYAL AGRICULTURAL COLLEGE, CIRENCESTER, AND FIRST ASSISTANT IN DR. VOELCKER'S PRIVATE LABORATORY

FORMERLY STUDENT OF THE ROYAL COLLEGE OF CHEMISTRY AND THE BIRKBECK LABORATORY OF UNIVERSITY COLLEGE

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PREVIOUS PREFATORY NOTES.

THE scope of this work being sufficiently defined in the following Introductory Remarks, a lengthy Preface is unnecessary. I need, therefore, only mention that I have been induced, by numerous applications for the book and the evident revived interest taken in questions concerning Artificial Manures, to undertake its revision, assisted by my nephew, Mr. A. E. SIBSON. No pains have been spared to modernise the information offered, and at the same time render it intelligible to ordinary agricultural readers.

I fully hope, therefore, my expectations of its increased usefulness may be realised.

ALFRED SIBSON.

JANUARY, 1895.
23, ST. MARY AXE,
LONDON, E.C.

IN preparing a brief introductory note to this new edition, rendered necessary by the exhaustion of the former one, I am pleased to say that my hope expressed in the foregoing remarks has been more than realised.

The rapid sale of the previous issue amply testifies the correctness of our surmise regarding the need for its publication, while the flattering expressions of approval from many quarters afford gratifying evidence that our efforts to make the book as useful as possible have not been unattended with success.

ALFRED SIBSON.

DECEMBER, 1895.
23, ST. MARY AXE,
LONDON, E.C.

PREFATORY NOTE TO PRESENT EDITION.

The earlier editions of this book having been exhausted some time since, and as frequent applications are made for it, the preparation of a further edition became obviously desirable.

In this third edition the object and range of the work remain unaltered, but we have carefully endeavoured to keep the subject matter abreast of recent advance, and to render the information given still more useful in explaining the nature and several uses of artificial manures, which daily experience continues to prove are assuming an increasingly important position as a factor in every description of produce raised from the soil.

Bearing this fact in mind there can be no question that the fuller the insight possessed by a cultivator of the land into this subject the better able will he be to make the best of his opportunities and to withstand the still prevalent agricultural depression. We therefore trust our little book may now enter upon an even more extended sphere of usefulness than in the past.

ALFRED SIBSON.

October, 1901,
23, St. Mary Axe,
London, E.C.

INTRODUCTORY REMARKS.

THE use and more just appreciation of Artificial Manures appear recently to have received a fresh impetus, as we have latterly been favoured with numerous applications concerning this book; and it is a fair assumption that much has still to be learned by farmers and other consumers regarding these fertilisers, while, unquestionably, as their knowledge increases, they are likely to employ them to better advantage. For the purpose of promoting a little wholesome emulation, we may mention that, as with those pursuing only too many other vocations, farmers on the Continent display a keener insight into the benefits secured by these articles, and are more fully aware how to purchase with true economy than our own. High-class Manures, which are necessarily costly, sell comparatively slowly here, but there, it is said, meet a ready demand, because the foreign buyers perceive that in

this way they often procure superior relative value than when dealing with lower qualities, while the mere rubbish frequently retailed amongst us as cheap fertilisers, whose price may be thirty or forty shillings per ton—a quite inadequate amount, of course, for any Artificial Manure worth having—to which, perhaps, another ten shillings or more must be added for carriage, would never be bought by intelligent Continental agriculturists.

Owing to the conditions under which modern agriculture is conducted, Artificial Manures have become a practical necessity, whomsoever may be the farmer—whether landlord, tenant or labourer; and although in numerous districts of this country we are constrained to deplore the sad plight of our leading industry, no reasonable doubt can exist that, if the land continues in cultivation at all, it will only be accomplished by means of some aid from manufactured fertilisers. Indeed, so strongly is this view held in certain quarters, that not unfrequently expressions are encountered which affirm their freer use to constitute the only remaining chance for procuring a living by farming. Certainly, regarding advantageous

expenditure of money, and the best methods for improving land generally, we should unhesitatingly recommend a judicious outlay upon Artificial Manures as amongst the wisest and most indispensable modes of procedure.

Considering, then, how important these fertilisers are, and also the necessity for chemical analysis in ascertaining their value, obviously it is desirable to provide plain and reliable guides which shall render an analysis certificate intelligible to practical men, and assist them in obtaining full advantage of those benefits a knowledge of materials at their command is able to confer. The following pages have been written with a desire to assist in attaining this end, and we believe our readers will find they supply much serviceable information concerning the subjects touched upon, for, in treating them, questions put to us by buyers and sellers of Manures and raw materials have received constant attention; moreover, for the purpose of avoiding unnecessary amplification, only those substances now actually employed in manufacture or of special interest are mentioned. Remarks and hints extracted from the author's Annual

Reports are embodied, concerning which marked appreciation has been expressed by a wide circle of clients.

We should state, perhaps, that the various recipes given are those for which our usual fees have hitherto been charged, and in no respect are they inferior to others procured at much greater expense; nevertheless, as our age is one of publicity, we offer them free of cost to those interested, hoping for corresponding, if indirect, compensation.

ARTIFICIAL MANURES.

SECTION I.

MAKING MANURES.

APPLICATIONS requesting directions for making superphosphate and other artificial manures being frequently addressed to us by intending manufacturers and farmers, it appeared desirable to publish in a concise form the substance of our replies. Upon these, therefore, the following pages are based, accompanied by such remarks and extensions as seemed necessary during their preparation. We trust also, that in addition to the inquirers mentioned, persons already capable of making manures satisfactorily, may find our information not uninteresting or valueless, although, doubtless, in some respects previously familiar.

Probably fewer farmers than formerly now desire to make the artificial manures they require, at least so far as regards dissolving raw phosphatic materials with acid, but the practice of compounding special fertilisers by dry mixing appears to be extending.

By thus publicly discussing the preparation of these fertilisers, we betray no trade secrets, since their ingredients have become perfectly well known, and are procurable in large or small quantities; furthermore, the manufacturing processes being simple, any one who wishes may prepare his own supplies in preference to buying; whether this course is upon the whole advisable will be considered hereafter.

For making such manures the chief requirements are raw phosphatic materials, suitable nitrogenous substances, and sulphuric acid or oil of vitriol. As to the first—we have at our disposal not only the longest known source of phosphoric acid, viz., bone, but also any of the various mineral phosphates now in the market. These, of course, differ greatly in relative merit, and are generally regarded as inferior to bone, which is unquestionably true while in an insoluble condition, yet when treated with acid they furnish equally valuable soluble phosphate.

Nitrogenous substances again are numerous, also being met with in all grades of quality and usefulness, but whereas new phosphatic deposits are constantly coming to light, fresh sources of nitrogen in any quantity rarely present themselves, consequently the latter materials acquire a higher natural and commercial value than the foregoing. This remark may be applied quite as truly to bones,

guano, dried fish, etc., which provide both nitrogen and phosphates.

All raw phosphates used for dissolving contain bone phosphate (tricalcic phosphate), an insoluble compound, associated with various impurities, amongst which the most important are carbonate of lime (calcium carbonate), earthy or silicious matters, oxide of iron, and alumina. Obviously the value of phosphates must be mainly dependent upon their percentage of tricalcic phosphate, but also on the amounts of the two last named impurities which are now considered of more importance than carbonate of lime for reasons that will become evident subsequently.

Modern artificial manure manufacture may be said to have originated in a suggestion of the illustrious Liebig for rendering bones more efficacious as fertilisers through the influence of sulphuric acid, a practice naturally extending as time advanced, to bone ash, and ultimately mineral phosphates. Subjected to this treatment the activity of bones became so strikingly increased that a rapid extension in the production of these vitriolised bones, as they were at first termed, took place, which, together with that of other descriptions of dissolved manures, has now attained enormous dimensions and largely superseded the application of raw bone, except for special purposes.

The demand for superphosphate having developed so greatly would render our obtainable supply of bones quite insufficient to provide material for manufacturing a hundredth part of the quantity required, this one fact demonstrating conclusively how invaluable an acquisition must the discovery of mineral phosphates be considered.

Manufacturers making superphosphate and similar manures on the large scale, of course purchase great quantities of raw phosphates at a time; sometimes a single transaction refers to two or three thousand tons; most varieties, owing to their rough condition, then require grinding in specially designed mills. This process of reduction is an expensive item as the materials are generally exceedingly hard, a high degree of fineness being also necessary, for the resulting powder must approach flour in impalpability, because the art of using phosphates most advantageously depends very much upon efficient pulverisation, a fact only properly understood during comparatively late years, and now apparently not always appreciated.

The practice adopted at most large manure works, of producing their own sulphuric acid, offers under these circumstances numerous obvious advantages. Any detailed description concerning the process of acid manufacture or the machinery and apparatus employed, would clearly be out of place in a short

treatise, but, some general idea regarding them being desirable, the following brief outline may prove serviceable to our readers.

Sulphuric acid (oil of vitriol) is made by burning sulphur, commonly called brimstone, or pyrites, a substance containing this element combined with iron, etc., in suitable furnaces, or "burners," so arranged that the sulphurous acid gas produced may receive an addition of sufficient air to furnish oxygen for its conversion into sulphuric acid. These mixed gases, together with nitric acid vapour, obtained through the action of strong sulphuric acid upon nitrate of soda (sodium nitrate) contained in an iron pan heated by the ignited sulphur, then enter a series of leaden chambers whose floors are covered with water to the depth of about two inches, steam jets being also introduced at different points; under such conditions nitrous anhydride and sulphuric acid form, the latter mixing with the shallow layer of water previously mentioned. This process is allowed to continue until the liquid attains a specific gravity of 1·55-1·60, these figures representing its weight compared to an equal volume of water; it is now withdrawn, and, if desired, further concentrated in appropriate apparatus to produce ordinary commercial oil of vitriol, although the weaker original solution answers for certain important purposes, amongst them the manure manufacturers', unless supplies are purchased

when brown acid, specific gravity 1·70-1·75, is procured, on account of reducing cost for carriage, and afterwards suitably diluted. The acid obtained after a final and expensive concentration is strong oil of vitriol, whose specific gravity is about 1·84, *i.e.*, nearly twice as heavy as water.

The specific gravity of sulphuric acid, which indicates its strength, is usually ascertained by hydrometers provided with "Twaddell's" scale, a sufficiently accurate plan generally, but less so than direct determination on a chemical balance.

The relation between Twaddell's figures and specific gravity is exceedingly simple; to find the latter we multiply the former by 5 and place 1· in front of the product, thus 150° multiplied by 5 equals 750, add 1·, making 1·750, the specific gravity of brown acid, which on Twaddell's scale is 150°, and chamber acid, specific gravity 1·60, 120°. Should we wish to convert specific gravity into strength Twaddell, the converse of this method is applied; for example, from the foregoing result 1·750 deduct 1·, and divide 750 by 5, which gives 150°. If two figures only are placed after the decimal point, say 1·75, a nought must follow what in the present case would be 15.

Nitrate of soda constitutes the most expensive item in making sulphuric acid. Theoretically the materials furnished by it might be expected to

serve indefinitely, as they apparently merely induce combination between atmospheric oxygen and sulphurous acid gas; in practice, however, more or less loss occurs according to the care exercised by attendants; about 5 to 7 per cent. is the average, but under bad management any figure may be attained. For this reason mainly it is not profitable to manufacture acid on a small scale, careful and trustworthy men, who rightly require good payment, being indispensable. The introduction of certain chambers named after their inventors, "Gay-Lussac" and "Glover" towers respectively, provided means for reducing all loss to a minimum.

The pyrites used for supplying sulphurous acid gas contains about 50 per cent. of sulphur; excepting not more than 5 per cent. remaining in the cinder or burned residue, all this should be available, a less complete extraction indicating mismanagement and consequent waste; more thorough exhaustion frequently occurs.

The proportion of true sulphuric acid present in that of different strengths is found by referring to a table (Ures) which states the percentage of both anhydrous acid and oil of vitriol (o. v.). For example, brown acid, whose specific gravity we know is 1·75, contains 83-84 per cent. o. v., and about 68½ per cent. anhydrous acid. More commonly brown acid possesses a specific gravity of 1·70-1·71,

and then has some 80 per cent. o. v., with about 65 of anhydrous acid. Chamber acid generally indicates 1·60 specific gravity, approximately representing 70 per cent. o. v. or 57½ of anhydrous acid. With these data it becomes easy to express a given quantity of any particular strength in terms of some other.

Before proceeding to discuss the preparation of manures in greater detail, some information concerning their raw materials should be acquired, which we accordingly endeavour to supply, commencing with a description of substances employed as sources of phosphoric acid. The method adopted for stating analyses is that followed in the author's ordinary certificates, and closely resembles systems employed by most other analysts. The examples given have been selected from a large number of samples submitted to us for examination, and are therefore quite representative, all results, moreover, being of recent date. These instances could be largely increased it we wished to amplify this section of our subject, but sufficient are mentioned for the object in view.

Phosphatic Materials.

Amongst these, South Carolina river phosphate still occupies a prominent position, and the following table shows some recent analyses of the material :—

Composition of South Carolina River Phosphate.

Dried at 212 Degs. F.	1.	2.	3.
Moisture	—	—	—
*Phosphoric acid	26·41	25·86	24·07
Lime	44·08	43·38	42·98
Other constituents not determined	18·87	19·37	19·66
Insoluble silicious matters ...	10·64	11·39	13·29
	100·00	100·00	100·00
*Equal to tribasic phosphate of lime	57·65	56·45	52·54

This phosphate is well liked by manufacturers, for, in addition to yielding a good percentage of soluble, it consumes very little acid unprofitably, because while containing some small amount of carbonate of lime (calcium carbonate) there is no excessive quantity, about 6-7 per cent. being an average; the oxide of iron and alumina are also low generally, and fairly regular, consequently determination of these two constituents in samples is not usually required: an estimation we recently carried out, however, showed ·94 per cent. oxide of iron, and ·48 alumina; any small quantity of iron present, as pyrites, is not included here, as it remains undecomposed by the sulphuric acid treatment adopted in making manure. A specially noteworthy advantage distinguishing phosphates of this order from most others occurs in the fact that those poorer in phosphoric acid possess an equal value per unit with the richer qualities, their inferiority

being due only to a little additional silicious matter which neither wastes acid nor complicates its action on the phosphate. The foregoing analyses refer to "river rock," which is chiefly used; it has a dark grey colour, and varies somewhat in composition, as our table explains. These results, we should observe, are given on the "dry basis," moisture, as a rule, being determined in separate samples; its proportion fluctuates greatly.

The "LAND ROCK" is met with far less frequently, although also a nice material, being similar in composition to the river phosphate, but of rather lighter and browner colour; a subsequent table contains an analysis.

COMPOSITION OF FLORIDA HIGH GRADE PHOSPHATE.

Dried at 212 Degs. F.	1.	2.	3.
Moisture	—	—	—
*Phosphoric acid	35·88	37·13	34·98
Lime	51·40	53·48	49·20
Oxide of iron...	·85	·26	·75
Alumina	1·58	·44	1·84
Other constituents not determined	6·09	5·41	4·90
Insoluble matters	4·20	3·28	8·33
	100·00	100·00	100·00
*Equal to tribasic phosphate of lime	78·33	81·05	76·36

This table contains examples of another largely employed phosphate, and a glance at the figures

immediately brings to notice useful qualities, an impression confirmed by practical experience, and when introduced, its reception proved so favourable that a wide and general demand rapidly rose. Further examination of the analyses—and we may notice that our previous remarks concerning "dry basis" and moisture samples apply here and to all similar cases—discloses somewhat marked variations in composition amongst the samples represented, which were selected as new and typical examples from large numbers, a difference amounting to nearly 5 per cent. occurring between the highest and lowest phosphate of lime shown. The exceptional richness of the substance in this most important ingredient should not be overlooked, as it is a point demanding peculiar attention, because the deposits being extensive, and therefore not quickly exhausted, we may anticipate abundant supplies, a very influential factor, for while always valuable in preparing concentrated superphosphate or strengthening lower grade materials, these high-class phosphates are not particularly plentiful. Another consideration is the proportion of oxide of iron and alumina, the latter, as we see, predominating; which, although unmistakably more than in South Carolina, cannot, where superior qualities are concerned, be called large, moreover, but little has been heard with reference to reversion caused by their presence in this

material; nevertheless, they constitute a distinct drawback, particularly the proportion occurring in lower grades, and their correct estimation becomes very necessary as a notable degree of variableness prevails; furthermore, when the combined percentages of these components exceed 3·0, the material becomes proportionately less valuable, obviously rendering the question a serious one. On this account oxide of iron and alumina determination has received thorough investigation from chemists and merchants, with the consequence that any difference affecting these united items greater than ·5 per cent. is now not thought allowable between two analysts' results. We shall have occasion to explain at a later stage the term "reversion" mentioned above, together with those causes making oxide of iron and alumina objectionable. In addition to the constituents stated, Florida phosphate also contains about 3 per cent. carbonate of lime (calcium carbonate) and a little fluorine.

Composition of :—

Dried at 212 Degs. F.	Tennessee Phosphate. 1.	Tennessee Phosphate. 2.	Land Pebble Phosphate.
Moisture	—	—	—
*Phosphoric acid ...	36·64	36·20	33·48
Lime	50·36	—	44·29
Oxide of iron	1·90	2·34	1·60
Alumina	1·48	1·42	1·22
Other constituents not determined	7·47	—	10·78
Insoluble silicious matters	2·15	—	8·63
	100·00	—	100·00
*Equal to tribasic phosphate of lime ...	79·98	79·07	73·09

Tennessee phosphate is now a prominent material, and yields a high percentage of phosphate of lime, as the table shows; it contains, however, rather much oxide of iron and alumina. In the second example only the more important items of the analysis are given.

Land pebble phosphate is at present chiefly used on the Continent, but merits careful trial in this country. The phosphate of lime varies from 68 to 75 per cent., and the united percentages of oxide of iron and alumina amount to 3 or 3½, a not excessive quantity, and the phosphate possesses no other qualities to which exception could be taken.

Composition of Algerian Phosphate.

Dried at 212 Degs. F.	1.	2.	3
Moisture	—	—	—
*Phosphoric acid	30·27	29·23	27·61
Lime	53·39	52·78	53·70
Oxide of Iron ... ... / Alumina	·70	·81	·78
Other constituents not determined	14·01	15·32	15·84
Insoluble silicious matters... ...	1·63	1·86	2·07
	100·00	100·00	100·00
*Equal to tribasic phosphate of lime	66·08	63·81	60·27

Algerian Phosphate receives a good share of attention. Analysis indicates that in it we are presented with a material of useful quality regarding phosphate of lime, and one, moreover, notably free from injurious substances, the combined percentages of oxide of iron and alumina being, as reference to our table shows, very slightly over ·75, which is, of course, exceptionally low. In physical character it is comparatively soft and easy to work, the colour being a peculiar greyish-white. Rather much carbonate of lime is present, but not in objectionable quantities—12 to 14 per cent. may be considered a fair approximate average; the determination of this constituent in phosphates is not generally required, unless some special reason exists; for instance, in any new unknown substance an estimation becomes desirable, because a little more or less is easily

equalised by slightly modifying the proportion of acid; moreover, carbonate in reasonable amount proves advantageous, promoting by its action satisfactory drying properties and requisite porosity, consequently compared with material quantities of oxide of iron and alumina, its significance is very trifling. We should not fail also to observe how small is the percentage of silicious matters contained in Algerian phosphate.

Gafsa phosphate has been met with, and if forthcoming in quantity promises well; an example appears in a later table.

COMPOSITION OF:—

	French Phosphate. 1.	French Phosphate. 2.	Belgian Phosphate.
Phosphoric acid ...	23·08	23·72	19·34
Equal to tribasic phosphate of lime ...	50·38	51·78	42·22
Oxide of iron and alumina	·76	·79	·48
Insoluble silicious matters	1·16	·46	·70

The French phosphates mentioned above and sometimes called Somme phosphate, are very generally employed, and although not of high grade dissolve very readily yielding an excellent superphosphate in which practically the whole of the phosphoric acid is rendered soluble. The older kinds of Somme phosphate wherein a considerable

amount of oxide of iron and alumina was not unfrequently found, do not seem to be much used now.

Belgian Phosphate, while not a rich material, has useful properties, because, although containing much carbonate of lime, the oxide of iron and alumina are well under 1 per cent.; it also dissolves with great readiness, consequently a considerable quantity is employed for admixture with minerals yielding high percentages of phosphoric acid, but themselves affording little carbonate, whereby advantages are secured unaccompanied by objectionable components. In appearance Belgian phosphate might be easily mistaken for sand, their colour and other physical characteristics being curiously alike.

Composition of :—

Dried at 212 Degs. F.	Pebble Phosphate.	Gafsa Phosphate.	Peace River Phosphate.
Moisture	—	—	—
*Phosphoric acid ...	31·40	26·83	27·82
Lime	47·06	—	43·68
Oxide of iron	·80 }	·28 }	13·60 }
Alumina	·98 }		
Other constituents not determined	10·06	— }	
Insoluble silicious matters	9·70	—	14·90
	100·00	—	100·00
*Equal to tribasic phosphate of lime ...	68·54	58·57	60·73

PEBBLE PHOSPHATE, although not very largely dealt with, provides an excellent raw material, for, while rich in phosphoric acid, it is favourably constituted regarding undesirable ingredients; and, moreover, in common with the land pebble phosphate previously referred to, it possesses naturally an excellent mechanical condition, occurring as comparatively small even fragments, a circumstance which manifestly greatly expedites the grinding process; consequently upon these facts becoming more generally understood, a ready sale may be anticipated.

PEACE RIVER PHOSPHATE again, the third analysis of this group, has been very favourably received, and is now frequently employed. With reference to composition, it is a decidedly valuable material, very similar in many respects to South Carolina phosphate; they are, therefore, frequently used interchangeably, as circumstances warrant. Physically it is an extremely nice article, assuming the form of rounded blackish granules remarkably regular in size, and closely resembling a coarse variety of gunpowder, a fact which renders it distinctly more manageable for reducing to a fine condition than larger and less even masses.

COMPOSITION OF :—

	Curacao Phosphate.	Aruba Phosphate.	Cambridge Coprolites.
Moisture	·54	—	1·30
*Phosphoric acid ...	39·75	33·40	26·54
Lime	53·80	47·13	43·76
Other constituents not determined	5·91	18·75	21·22
Insoluble silicious matters	traces	·72	7·18
	100·00	100·00	100·00
*Equal to tribasic phosphate of lime ...	86·77	72·91	57·93

The immediately foregoing table exhibits substances whose composition is obviously widely dissimilar.

CURACAO PHOSPHATE may justly be regarded as the purest and richest mineral source of phosphoric acid hitherto discovered. Although occurring in deposits of considerable magnitude various reasons prevent any very notable quantity appearing on the market; a speedy removal of such difficulties is unquestionably desirable, for plentiful supplies offered under favourable circumstances would assuredly find ready purchasers. This phosphate possesses some degree of hardness, and in colour is almost white.

ARUBA PHOSPHATE is retained as of past interest, but hardly demands comment on its properties further than an analysis affords.

Cambridge Coprolites at one time constituted the best known, and most generally used raw phosphate, now, however, the consumption has practically ceased. They occur in beds as small bluish-grey nodules, those samples whose nodules are largest being of superior quality. As a glance at the accompanying analysis will disclose, a close resemblance may be traced between this material and South Carolina phosphate, but unlike that substance the lower grades do not equal in relative value those of higher quality, oxide of iron and alumina exhibiting a marked tendency to increase; nevertheless the amount present is smaller than in Suffolk and other brown coprolites now almost entirely disused.

Composition of:—

	Somme Phosphate. High.	Somme Phosphate. Low.	Osso Phosphate.
Phosphoric acid ...	33·10	24·73	26·34
Equal to tribasic phosphate of lime ...	72·26	53·98	57·50
Oxide of iron and alumina	2·14	5·10	3·75

Somme Phosphate of the older sort may next be mentioned, although, as we have said, it is not now employed to any great extent. As the examples given show, it is subject to great variations in composition, not merely regarding phosphoric acid, but oxide of iron and alumina, in somewhat excessive amounts, are not unfrequently discovered, a fact for

which the strongly-marked brown colour would naturally prepare us.

OSSO PHOSPHATE exhibits properties so nearly resembling those described under the preceding heading, that any details beyond an analysis would be superfluous.

COMPOSITION OF :—

	Bone Ash.	Canadian Phosphate.	S.C. Land Rock.
Moisture	6·10	traces	5·04
*Phosphoric acid	33·28	35·30	25·81
Lime	41·13	47·22	37·34
Other constituents not determined	8·99	11·98	17·48
Insoluble silicious matters	10·50	5·50	14·33
	100·00	100·00	100·00
*Equal to tribasic phosphate of lime	72·10	77·06	56·34

BONE ASH, although now but little used, supplies a raw material admirably adapted for conversion into superphosphate, the process taking place more easily than with most other phosphates. We might, perhaps, not unreasonably suppose that its composition would prove very regular, but, owing to varying proportions of moisture and dirt, this is by no means true, from 60 to 80 per cent. constituting limits between which the phosphate of lime generally fluctuates, although in picked samples considerably higher figures may be obtained. The

richness of superphosphates thus prepared must evidently be entirely dependent upon so important a factor.

CANADIAN PHOSPHATE is likewise seldom employed. In this substance also marked differences concerning percentage composition are observed, our example being a high quality sample. Physically it is exceedingly hard and refractory, while apatite, the mineralogical name, alludes to mistakes made in its early analysis, showing that chemically, too, it proves particularly difficult to deal with. For securing good results by dissolving, extremely fine grinding is absolutely essential, otherwise the acid can act but feebly, and disappointment inevitably follows.

A brief notice relating to land rock occurs earlier, below that bearing upon river phosphate; the result shown is somewhat low, higher quality samples being met with.

Christmas Island phosphate is a new high grade material the supplies of which are apparently mainly taken by the Continent.

BONE BLACK OR ANIMAL CHARCOAL forms a valuable ingredient for manures, and is much liked; supplies, however, are very limited. It consists ot siftings from freshly-made material, together with the remainder when no longer serviceable for decolorising purposes. We occasionally come across

specimens of imitation bone black, prepared apparently from shale, against which buyers should be on their guard, as they contain no fertilising elements.

The phosphates hitherto mentioned contain phosphoric acid in combination with lime, a few units per cent. only occurring, as iron and alumina compounds; from time to time, however, materials have been introduced wherein this order is reversed, phosphates of iron and alumina predominating, Rodonda and Alta Vela phosphates being examples in the past. Between these extremes we find numerous intermediate substances, but all are practically useless to British manure manufacturers, whose endeavour must be to procure a large proportion of soluble phosphate for which these do not answer; in countries where this constituent receives less attention any objection of the kind exercises correspondingly diminished influence. When applied directly to land without previously dissolving, we should consider such samples having their phosphoric acid united with much oxide of iron and alumina as of some small value dependent on how far they are "mineralised," and also on the degree of fineness in grinding. The same may be said of the low grades of phosphate of lime sometimes used in this manner.

A careful perusal of our observations regarding phosphates must, we believe, suggest with peculiar

emphasis the great importance attaching to their reliable analysis, because, while incessantly varying materially, and transactions in large quantities being customary, heavy losses may follow what at first sight might appear insignificant discrepancies, amongst chemists' results especially, as modern competition allows small margin for profit on the manufactured product. Merchants are now fully alive to these facts, and yearly demand closer agreement on their analysts' part, requiring continual reduction in the allowable limits of difference. Such requests, when couched in the present reasonable terms, afford satisfaction rather than the reverse to competent men; but the enforcement of so high a standard has rendered essential extraordinary care in sampling cargoes, for obviously, unless precisely similar portions be examined, strictly comparable results become impossible, however correctly a chemist may work; therefore greater watchfulness and various refinements have been introduced, until now, by means of automatic samplers and other improved methods, our leading firms secure remarkably representative and uniform samples.

NITROGENOUS MATERIALS.

BONES.—Passing from the consideration of phosphatic ingredients to those providing nitrogen, we instinctively suggest as an initial step some explana-

tion regarding bones, which supply both, for although mentioned later under our section treating of "buying" manures, a brief reference here is indispensable, a method also adopted with various other materials employed for direct application in addition to dissolving purposes.

Although the two-fold qualification to serve as a source of plant food just claimed for bones is perfectly correct, both their nitrogen and phosphoric acid occurring, moreover, in a condition specially suitable for manurial constituents, they chiefly furnish the latter compound, because unlike most organic substances which contain but little mineral matter, *i.e.*, bodies not dissipated by burning, some two-third parts of bones consist of such components, mainly phosphate of lime, the remaining one-third including amongst other things *ossein*, a nitrogenous product yielding gelatine when suitably treated. In a subsequent page we shall have occasion to point out various modifications of composition and character induced by different modes of treatment, where also illustrative chemical analyses may be more appropriately inserted.

Besides bones, numerous other materials are employed to furnish nitrogen in nitro-phosphates and similar manures intended to supply this element together with soluble and insoluble phosphates.

Dried Fish of various descriptions constitutes an

admirable ingredient, being perfectly manageable and cleanly, also, like bones, providing both nitrogen and phosphoric acid. Considerable quantities are now dissolved with excellent results, producing exceedingly nice samples; the practice, however, deserves developing more fully, because by employing rougher preparations than the superior fish manures at present available, which are needlessly refined and costly for dissolving purposes, still better financial returns would appear; such a product might readily be prepared in existing factories by drying up sufficiently for convenient portability every description of fish refuse almost indiscriminately, excluding only that procured from shell fish. Materials of this class are chiefly valued for their nitrogen which they offer in an excellent and cheap form, at the same time providing what is even more important, a practically inexhaustible supply, as, ir we assume the demand to greatly exceed the quantity at present obtainable, America has undoubtedly proved that it would pay to specially catch and prepare non-edible fish. Thus we observe, if actively carried on, a wise utilisation of waste fish may afford some small compensation for the lamentably enormous loss of plant food in the sea, due to our, generally speaking, hopelessly unscientific sewage disposal system.

SULPHATE OF AMMONIA forms a highly valuable

component of manures for imparting a percentage of nitrogen quite unattainable by bones and similar materials, as it is the most concentrated available source of that element; moreover, although a soluble salt, and therefore more readily removed from land through drainage than organic matters, yet soils display considerable retentive properties towards it. As a separate nitrogenous manure this salt is again mentioned on a future page, where a table of analyses is also given.

NITRATE OF SODA may here be noticed as a source of nitrogen in compound manures, although a further and more detailed reference must appear later. While available with even greater readiness than the preceding salt, it is less suitable as a component of mixed manures, and moreover possesses a lower proportion of nitrogen, for whereas we find that the former furnishes over 24 per cent. of ammonia, the latter equals only 19, therefore 112 lb. of sulphate correspond to 141 lb. of commercially pure 95 per cent. nitrate. We need hardly say nitrate of soda must not be mixed in with the acid in the dissolving process, although instances of its being so used have come to our knowledge, and even for dry mixing certain indispensable precautions demand attention where it is employed as an ingredient of mixed manures prepared with sulphuric acid, because, theoretically, contact between these two

substances will be attended by decomposition and waste of nitrate; if dry superphosphate, dissolved bone, etc., are used, however, any such risk becomes greatly minimised and practically negligible, but admixture with freshly dissolved manure should never take place. Again we need to be aware that manures containing nitrate acquire a damp appearance, as this salt possesses deliquescent properties; another point of material importance to all concerned being, that nitrogen so supplied, may, unless specially sought by suitable methods, escape detection in analysis, being in a totally different form to that in ammonia compounds, etc., consequently some mention of its presence in samples sent to a chemist is advisable.

Shoddy or Wool Refuse is the final destination of all woollen fabrics when their fibre has become too short or otherwise unsuitable for respinning. In a raw condition materials of this class are particularly slowly decomposed in the soil, and rendered available as plant food, consequently, although sometimes used for direct application, the practice cannot be advocated as worthy of general adoption, especially when we consider that by treatment with sulphuric acid its character becomes completely changed, thereby providing a valuable and abundant source of nitrogen for dissolved bone compounds, etc., equal in every respect to that supplied by other

forms of organic matter. By the ordinary processes of admixture it is impossible to include much shoddy in a manure owing to its great bulk, thus obviously restricting the nitrogen percentage obtainable some 5 cwt. in a mixture whose total weight is 40 cwt. will yield about 1 per cent. of ammonia. When, however, we desire to employ larger quantities of this material, we may accomplish our purpose by means of special methods which enable us to prepare fertilisers showing from 4 to 6 per cent. of ammonia. The mode of procedure referred to consists of treating these raw substances with hot sulphuric acid in excess, which acts vigorously upon them, dissolving large quantities, and then allowing the product to form part of the acid required for preparing compound manures.

The composition of shoddy is exceedingly variable; its manurial value depends entirely upon the percentage of nitrogen, which is regulated by a sample's richness in wool, and consequent freedom from useless ingredients; of these excessive moisture is most common and least easily detected, sometimes as much as 30 or 40 per cent. and over may be found, about 15 to 20, however, is an average amount. Wherefore water is evidently a highly important factor in relation to shoddy, and one constantly giving rise to disputes through the differences in analyses it causes, for which chemists are sometimes

blamed, although unjustly, because the true reason we shall often discover must be sought in the system of conveying from place to place by means of open trucks; consequently the type of weather experienced during a journey exercises paramount influence regarding reduction of manurial usefulness; a consignment giving one result before being despatched yields quite another upon arrival at its destination if soaked with heavy rain in transit, increased uncertainty arising from the probable unequal saturation of upper and lower layers. Theoretically, of course, the total weight being proportionally greater through the added water, corresponding allowances might be made upon every ton, say; employed practically, however, men competent to judge consider this plan does not answer, any refinements of weighing proving impossible with such an article.

Shoddy often contains more or less non-nitrogenous fibrous substances such as cotton and hemp; latterly, however, some peculiar constituent has appeared, presenting the external characteristics of wool, but being in reality chiefly vegetable matter; these samples, therefore, when analysed give very low results. Some quantity of grease is also sometimes found on account of imperfect extraction; its presence renders heating more liable.

If employed for direct application, inferior partially

decayed shoddy, except samples containing much vegetable fibre, these often proving almost worthless, are not uncommonly most desirable, although offensive and damp, because the nitrogen in part exists as ammonia compounds, and the rest, *i.e.*, substances more or less decomposed, is naturally broken down with greater readiness.

WOOL-DUST OR FLOCK-DUST is a superior variety of shoddy, occurring in the form of fine dusty powder, and containing nitrogen equal to 10 or 12 per cent. of ammonia. Other allied, although inferior, materials yielding 5 to 6 per cent. of ammonia are also met with, but require no further comment.

AZOTINE.—Many attempts have been made to prepare from shoddy a less cumbersome and intractable material, some proving successful, but when dealing with substances allowing so little profit, expense becomes the chief difficulty. Amongst the products considered satisfactory we must certainly place azotine, which is manufactured by continuing the process previously described of submitting shoddy in conjunction with other suitable ingredients to the action of hot acid until a dry, finely divided powder is obtained of excellent manurial value, a certain proportion of its nitrogen existing as ammoniacal salts.

BLOOD AND DRIED BLOOD.—The former, collected from slaughter-houses, furnishes a highly valued and

much-used source of nitrogen whose percentage in the natural material equals about 3 to 4 per cent. of ammonia. The latter, employed for similar purposes, is also extremely useful, but less effective proportionately, this being due to a frequent prevalence of excessive temperatures in drying, which impart a leathery character and render the nitrogen less available. When of best quality the quantity of this last-named element present in dried blood corresponds to about 15 per cent. of ammonia. Partially dried blood, furnishing 6 to 7 per cent. of ammonia, is an admirable product much appreciated.

HOOF AND HORN WASTE affords a useful concentrated source of nitrogen, the percentage of this element being similar to or higher than the amount found in dried blood. The nitrogen is the only constituent of manurial value, but the material in question is much employed to furnish that ingredient of plant food.

RAPE-DUST OR RAPE-CAKE, when, on account of composition or condition, unfit for feeding, yet constitutes a valuable ingredient of manures, as affording readily decomposable organic matter, a component often much needed by soils, yielding 5 or 6 per cent. of ammonia. Caution when purchasing is however very essential, for a sample quite recently analysed by us contained some 70 per cent. of dirt, and its nitrogen equalled only 1·33 per cent. ammonia.

Other damaged cakes which are frequently procurable at small cost may be similarly employed, either alone or as constituents of dissolved fertilisers, with excellent results.

Refuse Materials, except those especially rich in nitrogen, such as flesh, offal, horn, etc., receive but a limited application, as sources of that element which is prevented from attaining considerable proportion in a mixture containing them by the large amount of extraneous matter they also introduce; thus such a commodity with say 2 per cent. of ammonia, used in quantities similar to those employed for shoddy, would impart only ·25 to a manure; furthermore, oxide of iron, carbonate of lime, and other substances tending to reduce soluble phosphates, and consequently lowering the fertilising value of a mixture, frequently occur in waste matters; therefore we could not recommend their utilisation.

	Shoddy No. 1.	Shoddy No. 2.	Wool Dust.	Azotine.	Dried Blood.	Silk Waste.
Nitrogen, per cent. ...	7·90	6·20	9·70	6·19	12·40	12·20
Equal to ammonia ...	9·59	7·60	11·98	7·52	15·05	14·81

	Organic Manure.	Horn Dust.	Rape Dust.	Skin and Hide Refuse.	Sugar Scum.	Damaged Cotton Cake.
Nitrogen, per cent. .	3·3	13·69	4·93	1·29	2·80	5·70
Equal to ammonia .	4·01	16·63	5·98	1·56	3·40	6·92

	Scutch, Glue Refuse.	Fur Waste.	Sud Cake.	Leather Cuttings.	Crude Ammonia.
Nitrogen, per cent. ..	2·63	8·50	3·55	8·10	7·70
Equal to ammonia	3·20	10·32	4·30	9·83	9·35

We are now in a position to proceed to consider

THE DISSOLVING PROCESS.

When superphosphates are prepared on an extensive scale, the admixture of raw phosphate and acid is effected in large vessels or "mixers" by means of steam power. The "mixer's" position is subject to variation, sometimes being placed horizontally, at others inclined more or less diagonally; an axle, on which arms or stirrers are spirally arranged, passes through its length, whose revolution is intended to secure complete intermingling of the contents. Some manufacturers adopt a continuous process, when the mixing vessel is fixed at an angle, the materials operated upon entering the uppermost end, and after traversing the apparatus are discharged from the bottom. It is more general, however, to employ an intermittent arrangement, whereby successive batches or mixings are agitated separately in the mixer for two or three minutes and then entirely removed.

Again some works have the mixer elevated above the ground, when a large walled enclosure or "den" receives the manure. In others it is placed level with the earth, the product falling into excavated pits. Evidently, therefore, no precise rules are followed, scarcely any two vitriol or manure works being planned alike; the only recognised general

principle, not, however, always observed apparently, is to utilise to greatest advantage the situation and means at command, economising time and labour to the fullest extent consistent with efficient working.

For making on a small scale both ready ground phosphates and "brown" or else "chamber" acid should be purchased, strong wooden troughs about 9 ft. by 4ft. by 3 ft., pitched inside, being employed for mixing, and a wooden rake for stirring, which must be thorough.

When rates for carriage are not too high, chamber acid should be bought in preference to brown acid, the latter before using requiring dilution to reduce it to the strength of the former, but apart from the danger, which is considerable, of mixing strong acid with water, owing to the violent action induced and the corrosive effect of any splashes of the hot acid on one's skin or clothes, a further objection exists in the difficulty of securing sufficiently intimate mixture between these two liquids, which is much greater than we might suppose, while an evenly uniform strength throughout is essential to success.

On mixing the phosphate with the acid, a brisk action at first ensues, owing to the liberation of carbonic acid gas, steam, etc., but after a few minutes' stirring it subsides, and the creamy fluid gradually thickens and dries up, until in about

twenty-four hours, if properly made, it is sufficiently solid to allow of being removed if necessary.

The proportions in which to mix the materials are varied somewhat by different makers, but the following quantities are well adapted for preparing on either the large or small scale.

In these recipes the acid referred to is chamber acid, having a specific gravity of 1·57-1·60, otherwise about 114°-120° Twaddell. For bone manures a rather lower acid is sometimes used, about 1·55 specific gravity or 110° Twaddell. When the employment of brown acid becomes desirable, it may be reduced to the strength of chamber acid by adding to every cwt. 1½-2 gallons of water. A gallon of water weighs about 10 lbs.

MINERAL SUPERPHOSPHATE.—Raw mineral phosphates, whether treated singly or as mixtures of different kinds, for making ordinary superphosphate are best dissolved by adding 16-17 cwt. of acid to 20 cwt. of phosphate; for materials richer in phosphoric acid or those possessing much calcium carbonate, 17-19 cwt. of acid are required. Manures belonging to the first-mentioned type should give about 27-28 per cent. of soluble phosphate, and 3-5 insoluble, according to the quality of the raw phosphates employed, which should contain 55-58 per cent. tribasic phosphate of lime. Some makers adopt the plan of mixing five parts of acid with six

parts phosphates, obtaining good results. A larger quantity of weaker acid, say 1·55 specific gravity, is sometimes considered advisable when the product is expected to remain stored for a lengthened period.

Dissolved Bone Compound of good quality is obtained by admixture of 10 cwt. bones, 10 cwt. mineral phosphate, 15 cwt. acid, and 1-2 cwt. gypsum. This should yield about 20 per cent. soluble phosphate, 12-15 bone phosphate, and 1·3-1·5 of ammonia from bone. For a bone manure of lower quality 6-7 cwt. of bones may be used with 13-14 cwt. mineral phosphate and the nitrogen increased by 1-1½ cwt. of shoddy, which affords an excellent source of nitrogen when decomposed by acid as we have previously explained. If a higher percentage of nitrogen is required, it may be supplied by the addition of animal matter such as dried blood, hoof and horn waste, dried fish, etc., or in a much more condensed form as sulphate of ammonia.

It is a good plan in manufacturing bone manures to mix the mineral phosphate and acid first, adding the bone afterwards, the mineral thereby securing full benefit of the acid.

Pure Dissolved Bone.—For this we should recommend two-thirds bone with one-third acid. The bones employed need grinding to a fine meal,

they must also be dry and free from grease and extraneous animal matter, as only such give satisfactory results. Indian bones are especially suitable for the purpose. It is not easy to procure a high proportion of soluble phosphate together with good condition in this manure, but by first dissolving a portion of the bones in the acid, and using the remainder for drying the product, we may obtain from 12 to 15 per cent. soluble, about 18 per cent. insoluble bone phosphate, and $2\frac{3}{4}$ to $3\frac{1}{2}$ per cent. of ammonia, the article also being perfectly manageable. These manures require more time for drying than a mineral superphosphate, which, indeed, is the case with all samples containing much bone; furthermore, in common with almost all other artificial fertilisers, before being placed in bags for sale treatment by the disintegrator, to break down lumps, etc., is generally necessary, because much of the manufacturer's art consists of imparting good condition to his manures, and ensuring its retention until employed on the field. Many makers only guarantee the total bone phosphate in pure dissolved bones, as they often contain much reverted phosphate, a point receiving explanation later on.

VITRIOLISED BONES are usually made with a smaller proportion of acid, say 3-4 cwt. for a ton of bones, the same degree of fineness in grinding not being requisite.

Bones may be dissolved like guano by mixing with the acid on a paved or asphalte floor, making a rim or border of the dry material, which is then gradually incorporated, this method proving useful when much frothing takes place.

A good practical rule regarding the quantity of acid desirable is to give the phosphate, or mixture of phosphates, as much as it will take up and dry properly; it is bad policy to stint acid, since the value of the soluble phosphate is greater than that required to make the original phosphate, as far as practicable, all soluble, and it is impossible to do this without enough, or more than enough, theoretically. In fact, by sending out undissolved mineral phosphates in manure, we to a large extent waste them, because, although costing as much as that portion which is dissolved, they have little practical effect in the soil.

As a general rule, water if used should be added to the acid in preference to the phosphate; it must be carefully mixed with a portion of the acid and well stirred, and the remaining portion of the latter then added, otherwise the water will not be equally distributed, a condition, as we have seen, indispensable to success. It is less trouble to add the water to the phosphate, and afterwards the acid, but in this case the action is more violent, and the manure does not dry so well. A common source of inequality in

the product when making on the larger scale, is the varying concentration of the acid as drawn off from the chambers, in which it has been proved to lie in layers of different strengths; an effective means ot thoroughly mixing and testing the acid before use is therefore absolutely necessary for obtaining uniform quality fertilisers.

To satisfactorily prepare superphosphate and similar manures, it must be borne in mind that the proportions of materials constitute but one element of success, hence we do not guarantee the above results. Also it is scarcely possible to make at once a superphosphate which shall be all we could wish, but a few well-directed practical trials will generally indicate the best mode of employing the means at our command, and be more effectual than any elaborate directions, which, however detailed, can never dispense with the value of experience. The difficulty more commonly met with arises from the product not drying well, but when made for home use this may be avoided by a liberal addition of drying materials; nevertheless, it forms one of our reasons for rarely advising amateur efforts of the kind. The foregoing recipes, however, with common care and judgment, should not need much assistance in this way. A little more water may be used, if preferred, but the soluble phosphate will unavoidably be lowered thereby.

Apart from that of their nitrogen the value of these dissolved manures depends chiefly, as we well know, upon the amount of soluble phosphate they contain, the object in view being to decompose or render soluble as much as possible of the phosphate of lime present in the raw materials; or, otherwise expressed, to have as little as possible of the original phosphate unchanged by the acid, because this appears in analyses as insoluble phosphate, and has, of course, much less value, although the relative worth of insoluble derived from bone, and that originating in mineral sources, is totally different. The theory of the process is simple, and may be thus described: the natural phosphate of lime, as it occurs in all the raw phosphates, is composed of three equivalents or portions of lime and one of phosphoric acid (hence the term *tri*basic or *tri*calcic), and in this state is *insoluble* in water, or remains unaltered in that liquid. The sulphuric acid added, being stronger under ordinary circumstances than phosphoric acid, abstracts two of the three equivalents of lime to form sulphate of lime (gypsum), leaving the phosphoric acid combined with the remaining one equivalent of lime to form monocalcic phosphate, which is *soluble* in water, that is to say, dissolves or goes out of sight in this fluid just as sugar or salt does. Monocalcic phosphate constitutes, however, only one of the soluble forms of

phosphoric acid present, the change described being to a varying extent carried farther, and free phosphoric acid itself produced. The soluble phosphate signifies the amount of the tricalcic phosphate or natural phosphate of lime decomposed by sulphuric acid. This natural phosphate of lime is also sometimes called "bone earth," because it is the characteristic constituent of the bones of animals.

A few words here concerning the results of bones and ammonium sulphate as sources of nitrogen may be serviceable. Assuming the former to contain nitrogen equal to $4\frac{1}{2}$ per cent. of ammonia, it will require about 8 cwt. in a mixing of 40 cwt. to furnish ·90 per cent. of ammonia in the manure. With the concentration in weight taking place on mixing, and the small quantity of nitrogen always present from other sources, the actual quantity of ammonia in such a mixture, supposing no other source of nitrogen is to be used, will be rather more than 1 per cent. From this instance the amount of nitrogen to be expected from more or less bone will be easily estimated.

When ordinarily pure, sulphate of ammonia contains about one-fourth its weight of ammonia, therefore it is clear that 5 cwt. of it, mixed with 15 cwt. of other materials, will yield $6\frac{1}{4}$ per cent. of ammonia in the mixture, and so little as 1 cwt. in 20 will give $1\frac{1}{4}$ per cent. in the product. From these

examples any other proportion can be readily calculated. We have met with samples of sulphate of ammonia containing 26 and upwards per cent. of ammonia, due to the presence of chloride of ammonium, which is, of course, unobjectionable.

Were it not for the remarks sometimes expressed by persons imperfectly acquainted with the subject, it need hardly be said that good manures cannot be made without good materials, in adequate and proportionate quantities; although economy may be practised within certain limits, it is simply impossible to get a high percentage of soluble phosphate without using a good raw phosphate to begin with, and the requisite sufficiency of acid.

Regarding the weight of superphosphate or other manure produced from a given quantity of materials, this will obviously be equal to the weight of those materials *less* that portion of them volatilised in the mixing process. The extent of such loss varies of course with the ingredients employed and mode of preparation adopted, but from experiments made by one of us with the view of determining this point, it would appear to average about 7½ per cent. on the total weight of materials used, up to the time of the fertiliser reaching a moderately dry and manageable condition. If, as an illustration, one hundred tons of coprolites are dissolved by an equal weight of chamber acid, we should therefore get, supposing

nothing else to be added, about one hundred and eighty-five tons of superphosphate.

In preparing superphosphates from raw materials containing little oxide of iron or alumina, the percentage of total phosphates in the manure can be calculated by the rule of simple proportion from the quantities of materials employed, the composition of the latter being ot course known. To extend the preceding example—if the coprolites had 58 per cent. of phosphate of lime (although this is rather above the present average), we should get 29 per cent., supposing no loss to have occurred in mixing, but taking the loss at the foregoing estimate, we should have the whole of the 58 tons in the 185 tons of superphosphate, or about $31\frac{1}{3}$ per cent. In the case of some phosphatic materials, however, a higher percentage of total phosphates is found than could possibly be furnished from the tribasic phosphates in the substances employed, which may be explained as follows. Such phosphates contain iron and alumina compounds, which in the ordinary process of analysis are weighed with the undissolved phosphate of lime as a mixture of insoluble phosphates. The further separation of these items could of course be effected, if desired, but this is not usually done by chemists, for the reason that the process is too lengthy to be employed in every case. Moreover, the omission is of little or no consequence, inasmuch as the insoluble

phosphates, except when in the form of bone, are often left altogether out of consideration when valuing a manure, which we consider is hardly justifiable, also because in a well-made manure the insoluble phosphates, unless present as bone, are too small in quantity and value to warrant separation in analysis, which might also lead to confusion.

With reference to the relation between the total phosphates in manure, *i.e.*, the phosphate made soluble, together with the insoluble, and the acid employed. It is clearly evident that the less acid used, the more total phosphates will be present, but a smaller proportion will be soluble. The converse is also evident: viz., that the more acid used, the less total phosphates, but an increased relative quantity of them will be soluble, although not necessarily a higher percentage in the manure. Thus, supposing we were to use 200 parts of bone ash of 70 per cent. phosphate, and 100 parts of acid, we should have in the product 140 parts of total phosphate in 300 of material (omitting for simplicity the loss referred to above), or about $46\frac{2}{3}$ per cent., obviously indicating too little acid. If, on the other hand, 100 parts of bone ash were dissolved with 200 parts of acid, we have only 70 parts of total phosphate in the 300 of material, or some $23\frac{1}{3}$ per cent., showing an excess of acid the mean of these two amounts being correct. Although this is of course an extreme case, it is men-

tioned to prove the fact that beyond a certain point additional acid will lessen the percentage of soluble phosphate instead of increasing it—simply because it then brings down the total phosphates too low, notwithstanding that the whole of them may have become soluble as far as practicable.

Again, the addition of any extra quantity of water in mixing will manifestly lower the percentage of everything in a manure: many makers take no account of the weight of water used, and, when this is left to the men engaged in the operation, it affords the commonest source of variation in the product—especially as a little extra water gets the work on quicker; the better plan is to use a weaker acid and no water. If a bone manure, when freshly made, is found to contain (say) 25 per cent. of soluble, but does not dry up well, and it is thought advisable to add a little drying substance, the mass after the addition will not have 25 per cent., since the same amount of phosphate is diffused throughout the increased quantity of material. These statements may appear self-evident to some, but to others they would seem to be incomprehensible, judging by the correspondence sometimes received.

Concerning the soluble phosphate produced from a given weight of acid—the theoretical quantity to form monocalcic phosphate is 160 parts of anhydrous acid (SO_3) for 310 parts of tricalcic phosphate; or

for 100 parts of bone ash, as above, $55\frac{1}{2}$ parts of brown, and $62\frac{3}{4}$ chamber acid. From an analysis of raw phosphate it is of course possible to calculate the theoretical proportion of acid required, but as the results obtained are, for various reasons, only approximately correct in practice, we shall not enter more fully into this subject.

Phosphatic materials, however, in addition to tricalcic phosphate also, as we know, contain variable percentages of carbonate of lime with oxide of iron, alumina, etc.; but, making full allowance for the quantities these consume, it is found that more than the calculated amount of acid is always needed, which may be due to the following causes:—

(A.) The acid practically required, while exceeding that necessary for converting all the tricalcic into monocalcic phosphate, is far from sufficient to produce free phosphoric acid only; nevertheless, some is always present, and possibly explains the demand for surplus sulphuric acid, because raw materials used in preparing dissolved fertilisers are necessarily, even when most finely ground, very imperfectly divided; consequently, however efficient our mechanical arrangements, the interior of these comparatively coarse particles remains inaccessible when first mixed with acid, which continuing to act upon the external surfaces there proceeds farther than forming monocalcic phosphate, setting phos-

phoric acid at liberty, being consumed in undue amount for this purpose, and as in process of time the minute nodules of mineral phosphate become penetrated, the remainder, if theoretically exact for the whole originally, would not suffice to form monocalcic phosphate.

(B.) Acid is consumed in decomposing phosphates which are not rendered actually soluble, on which the question of precipitated phosphates probably throws some light. This is especially noticeable in well-made bone manures in which the greater part, and sometimes the whole of the bone, has evidently undergone decomposition, a supposition proved by its mellow and pulverulent condition, although when analysed only a portion of it is found to be dissolved by water.

Dry Mixing.

For several reasons, we should recommend farmers to buy rather than make their dissolved manures; it being wiser, in our opinion, to purchase these as a basis for home-made fertilisers, mixing in dry whatever other suitable constituents are required for producing those of a special character.

By securing guarantees with articles purchased, dissolved or otherwise, and obtaining an analysis when advisable, we are enabled to ensure procuring the desired qualities; for unless this condition

be fulfilled, satisfactory progress is, of course, impossible.

The materials employed for mixing with superphosphate, etc., are :—

Bones; either ½ inch, ¼ inch, or meal, and steamed bones.

Sulphate of ammonia, nitrate of soda.

Kainite, muriate of potash.

Common salt, gypsum; or any other diluent.

We offer the following recipe for a good turnip manure, placing it here merely as an illustration of such dry-mixed manures; other examples will appear in the "Using" division. The quantities shown are for a ton :—

14	cwt.	good mineral superphosphate, 26-28 per cent. soluble.
3	„	fine bone meal, 48-50 per cent. phosphate, and 4-5 ammonia.
1	„	sulphate of ammonia, 24-25 per cent. quality.
1	„	gypsum.
1	„	common salt.
20	„	= 1 ton.

A point demanding particular attention is the special care required to secure even distribution of so small a quantity of sulphate of ammonia or other important constituents throughout the much larger

bulk of accompanying components. We may accomplish this best by first intimately mixing it with the salt and gypsum, which are then added to the superphosphate and bone, the whole mass being allowed to lie in heaps as long as possible before beating down and sifting.

Upon analysis this mixture should contain approximately:—

17-18 per cent. soluble phosphate.
$7\frac{1}{2}$-9 „ „ insoluble phosphate, chiefly from bone.
2 „ „ ammonia.

Soluble phosphate may be rendered visible, and its characteristic property demonstrated, by a simple yet interesting experiment, which can be made as follows, without any chemical apparatus or materials: A little superphosphate (say a teaspoonful) is mixed with about two wineglassfuls of water in a tumbler, and stirred with a lead pencil. The soluble phosphate dissolves in the water, although no change is seen, in consequence of the insoluble matter also present, but if we remove this latter by straining, we may get a clear solution of the soluble phosphate in which its presence may be rendered manifest. The straining in this case can only be done by filtering, and to do this we take a piece of blotting-paper (white paper in preference) about six inches square, and fold it double, and again double at right angles,

so that on opening one side we get a cone or kind of cup, into which the above muddy liquid must be poured without overflowing the edges; the necessary support is afforded by resting the filter in the mouth of a tall ale glass. The liquid that passes through the paper should be as clear and bright as the water first used (a *solution* signifying a liquid in which a solid is taken up invisibly, except in the cases of coloured substances), and if not so must be rendered clear by again passing through the same filter. This clear fluid contains the soluble phosphate, which becomes apparent upon adding a little washing soda previously and separately dissolved in a small quantity of water; the white gelatinous substance so produced is the soluble phosphate once more rendered insoluble by the soda, and may be collected in the solid form on another filter. Another easily performed experiment, relating to the different forms of nitrogen, may also prove interesting. Procure three teacups, and into each place about a tablespoonful of lime, either quick or slaked, mixing into a thin paste with water, using lead pencils or penholders for stirring; arrange all three carefully in a row, then to No. 1, which may be on our left hand, add about a teaspoonful of nitrate of soda, stir briskly, smell, and observe that no perceptible change occurs. No. 2 receives a similar quantity of clean raw bones or horn

shavings, and is treated in a precisely similar manner, still nothing noticeable happens; lastly we turn to No. 3, and add the same amount of sulphate of ammonia, stir thoroughly, and smell cautiously, here we immediately detect a very different result, for a pungent odour of ammonia is given off. Our investigations illustrate very clearly what marked distinctions occur between these sources of nitrogen, a fact not sufficiently recognised generally, the third substance being the only one containing the element in the form of ammonia, although the words nitrogen and ammonia are often used indiscriminately by agriculturists; but as lime drives ammonia out ot its combinations, and nothing was evolved from the two other materials, they clearly contain none; the first affords nitrogen as nitric acid, and the second as organic matter. We must carefully observe, however, that our results are by no means designed to indicate inferiority in any of these cases, but only the importance of thoughtfully employing each in its proper place.

SECTION II.

BUYING MANURES.

The next point for consideration, already briefly mentioned, is whether to make or buy the superphosphates and other dissolved manures we require. If questioned by an ordinary agriculturist concerning the wisest course, our unhesitating reply would be the latter.

In favour of the first it has been said: First, that you save the maker and agent's profit; second, that you get the labour for little or nothing, by having it done at times when the men would be otherwise unprofitably occupied; third, that you know what is put into your manures, and so ensure freedom from adulteration. On the other hand, it may be said that we cannot possibly make to the same advantage on a small scale, with extemporised apparatus, as in properly arranged works, and that the profits of manufacturers and their agents are derived from sources not at the command of consumers or small dealers; for example, the greater facilities for purchasing materials in large quantities by means

of capital specially devoted to the purpose, which is indispensable to financial success, the manufacture of acid, and the application of steam-power to almost every operation that would have to be done on the small scale by hand. A further drawback to home making is the high rate charged by railway companies for the carriage of acid, which they consider a dangerous article; this is perhaps the most serious bar to making manures, except in localities where it can be otherwise obtained; furthermore, another objection is that the handling of sulphuric acid by inexperienced persons is, as previously mentioned, an unsatisfactory and decidedly risky matter, and such a consideration must evidently be weighed against apparent advantages in cost.

As regards genuineness, we must not forget that raw phosphates may be adulterated, or supplied of low quality, as well as manufactured manures; indeed, even now a source of inferiority in the latter is the tendency shown by some manufacturers to accept too readily the quality of raw materials. Analysis by competent chemists is the only possible guide in the purchase of all such articles, and to omit this precaution, for the purpose of saving a fee, is very false economy.

The strongest argument, however, against farmers preparing dissolved manures is the fact within the author's knowledge of more than one large farmer

who, originally impressed with the advantages of making for themselves, commenced in earnest to do so, succeeding to their entire satisfaction, producing manures fully equal in every respect to any on the market (which is more than every amateur can say), yet they afterwards abandoned the practice, finding it possible to buy cheaper.

Every one will, however, be able to judge for himself on this point, by calculating the cost of materials from the advertised price-lists for the quantities given in the foregoing recipes, with the cost of carriage for acid, etc., to his own place. It must be clearly understood, that while offering the preceding remarks as our candid opinion on the point in question, we have done our utmost to render the instructions for dissolving raw materials thoroughly reliable, and believe any one essaying to make use of them in practice will find they are so.

Mineral Superphosphates.

Whether to buy this material or some other dissolved fertiliser will, of course, depend on the object we have in view. When used in conjunction with farmyard dung a mineral superphosphate is often sufficient—in fact, without dung, but used freely, this kind of manure suffices on many soils to yield good root crops, although we do not recommend

the plan. Its manurial value is determined almost entirely by the soluble phosphate present.

In the case of dissolved bone, the undissolved portion is, of course, as valuable, or, as we have always contended, considerably superior to ordinary crushed bone, in consequence of the semi-dissolving process undergone. On the other hand, bone ash or mineral phosphates remaining undissolved possess a greatly inferior value, and should consequently be avoided as far as possible, although we cannot accept the view which considers that it is positively worthless for the following reason. In all alluvial soils of natural fertility we find the phosphoric acid in an insoluble condition, chiefly in the form of phosphate of iron or alumina—these bases having the power of decomposing any other phosphates originally present. Hence the same insoluble compounds must ultimately be formed, when phosphatic manures are applied to ordinary soils, in which hydrated oxide of iron and alumina abound.

Mineral superphosphates are made of all qualities—from 25 per cent. of soluble, and up to 40, and even much higher. The higher qualities are most suitable for special purposes, as, for instance, exportation to the colonies, where a high freight or long inland transport renders any reduction of weight particularly important. Rich superphosphates are, therefore, sometimes relatively cheaper than the

lower ones if care be taken to distribute them properly; that is, in proportionately smaller quantity per acre. One having 40 per cent. is of course twice as valuable as another having 20 per cent., and if used in half the quantity of the latter, would have an equally good effect, provided all necessary care be taken in its application. This, although self-evident, is often lost sight of in the employment of concentrated manures.

Ordinary mineral superphosphates should contain at least 26 per cent. soluble phosphate (tricalcic phosphate made soluble), although many reach 27, 28, and even 30 or more. Differences of this extent are frequently found in samples of one price.

As soluble phosphate is the chief item in mineral superphosphate of whatever quality, it is of course very necessary to know with certainty at least the proportion of this constituent. This should be ascertained by having a sample drawn from the bulk delivered tested by a competent chemist, for, however honestly we may be served, the intended percentage of soluble phosphate cannot always be ensured for various reasons which need not here be entered upon.

Pure Dissolved Bone, Dissolved Bone Compound, etc.

These are of course distinctly superior to the above, but of higher price; the bone left undis-

solved in them furnishes a more lasting supply of phosphate which becomes serviceable during the later stages of a crop's growth, and at the same time it also supplies nitrogenised organic matter.

PURE DISSOLVED BONE.—The distinction implied in the terms pure dissolved bone, and dissolved bone compound is, as we remark elsewhere, an important one for farmers to observe. The first-named, which during recent years has become far more largely manufactured and employed than formerly, must be prepared exclusively from pure unaltered bone and acid. At one time it was considered exceedingly difficult to obtain any satisfactory percentage of soluble in conjunction with manageable condition from such ingredients alone; these obstacles, however, have since been effectually surmounted, reference to the subsequent analysis revealing the normal amount of phosphate rendered soluble, while in physical character most samples are satisfactory. Necessarily, when desirous of purchasing fertilisers so carefully and expensively prepared, we shall have to pay a proportionate price, and must be correspondingly careful to ensure getting what is bargained for.

VITRIOLISED BONES.—This term, although sometimes employed in common with the above, is generally taken to mean a bone manure in which less acid is used, and consequently contains a

smaller percentage of soluble phosphate. For most purposes it is superior to unaltered raw bones as the soluble phosphate and more available nitrogen, although only small in quantity, saves time in supplying the needs of the crop. In this manure (and sometimes also in the foregoing) the total phosphate only is often guaranteed.

DISSOLVED BONE COMPOUND.—Under this title manures excellent in every way are to be obtained, having a high percentage of soluble and a good deal of insoluble phosphate in the form of well-softened bone, also yielding very satisfactory quantities of ammonia. These manures, however, are not made from bone only, the soluble present having a mineral origin, and part of the nitrogen occurring as various kinds of nitrogenous organic matter: fish, wool, etc., or sulphate of ammonia and sometimes nitrate of soda. It is highly important, nevertheless, that the insoluble phosphate should be derived from bone, either fresh or boiled, bone ash or mineral phosphate in this condition being much less useful, and one is little if any better than the other, as the author has proved by specially conducted experiments.

Regarding the relative merits of these two descriptions of manures, when procured at a suitable price, we consider the latter one of the most advantageous methods in which agriculturists can

spend their money for purposes of the kind, and may remark that a very high practical authority has communicated to us his conviction that in farming he has been quite unable to detect any difference between the action of soluble phosphate whether derived from bone or minerals, and is fully assured that one is just as good as the other.

We should not omit some reference here to the fact, touched upon elsewhere, that manures of the type we are considering, together with others to a less extent, often lose on keeping some of the soluble phosphate they at first contained, which now appears as reverted or precipitated phosphate, as soluble phosphate always exhibits an inclination to assume this insoluble condition through the influence of such substances as oxide of iron, organic matter, carbonate of lime, or even undissolved phosphate of lime.

The following table illustrates the composition of the manures we have described, the examples representing fairly average qualities :—

COMPOSITION OF :—

	Pure Dissolved Bone.	Dissolved Bone Compound.	Mineral Super-phosphate.
Moisture...	11·24	13·20	16·74
*Organic matter, etc. ...	28·68	17·14	8·16
Monophosphate of lime	9·73	12·82	17·15
Equal to bone phosphate made soluble... ...	(15·24)	(20·08)	(26·86)
Insoluble phosphates ...	18·50	12·68	4·38
Sulphate of lime, etc....	30·49	39·23	47·81
Insoluble silicious matters	1·36	4·93	5·76
	100·00	100·00	100·00
*Containing nitrogen ...	2·65	1·43	traces.
Equal to ammonia ...	3·21	1·73	

We determined the reverted phosphate in the pure dissolved bone, and found it amounted to 5·24 per cent.

Chemists adopt somewhat different modes ot stating their results, but in all cases the more essential constituents are the soluble phosphate, the insoluble phosphate, and the nitrogen equal to ammonia. The other components are of smaller importance, except nitrates and potash when they are present, both of which appear amongst the alkaline salts, and the nitrogen of the former should be added to that obtained from organic matter, etc.

Explanation of Constituents of Manures as Shown in Analyses.

As it is very desirable that farmers and other purchasers should clearly understand the wording and meaning of an analysis, the following explanation of the more commonly occurring constituents we hope will prove of service. The items are taken in the order usually adopted.

Moisture is the water unavoidably present with the acid employed; or added, if the stronger acid is used. A considerable proportion of this is again lost by drying when the manure is kept any length of time.

The question ot moisture is often one ot some importance to practical men, since it influences the proportions of other constituents on which the value of the manure depends. Thus as a quantity of manure dries, it of course decreases in total weight: if 100 tons, say, to begin with, and it loses but 5 per cent., there will now be only 95 tons. The $7\frac{1}{2}$ per cent. mentioned as loss in making superphosphates, part of which is moisture, it will be remembered, is the amount escaping during the attainment of a good manageable condition, which should be in a week or two after making,—but if kept for two or three months longer, the diminution will be considerably greater.

In the case of raw phosphates also the extent to which moisture influences the percentage of phosphate of lime is often striking, and might almost at times be doubted, were it not a matter of hard fact and figures, which any one can calculate as well as a chemist. For example, a sample which in the dry state gives 70 per cent. phosphate of lime, will, if calculated for the natural condition, with 10 per cent. of moisture, taking round numbers for the sake of simplicity, yield only 63 per cent.

ORGANIC MATTER is the general term applied by chemists to all substances of animal or vegetable origin which are burnt by heating or subject to decay. Thus hair, wool, cotton, sawdust, etc., are organic matter, although they possess very different manurial values. This factor is found to depend almost entirely on the amount of nitrogen present, or, in other words, on the quantity of ammonia they are capable of yielding by decomposition. For instance, hair, wool, horn, and most kinds of animal matter, except fat, contain much nitrogen, and are valuable as manure; while cotton, sawdust, bark, and similar bodies, have only traces of nitrogen and are almost worthless as fertilisers. Consequently we perceive the reason for stating this item in the manner shown by our table, viz., "Organic matter, etc., containing nitrogen, equal to ammonia." The total amount of organic matter or other bodies

occurring under this item is of little consequence, because it may be non-nitrogenous; but the further direct estimation of nitrogen, from which the ammonia is calculated, at once shows what kind of organic matter it is, and its manurial value. Associated with this item in an analysis, one often meets with the term "salts of ammonia," and also "water of combination."

Ammonia is an invisible gas like atmospheric air, but possesses a strong pungent odour familiar to all as giving off from smelling salts. We have in the preceding section described how this gaseous ammonia may be liberated from its compounds by means of lime, which will illustrate the distinction between fixed and free ammonia. The meaning of the latter term is obvious, while the former signifies that the compound is in a state of combination no longer exhibiting its pungent smell, and is incapable of flying off except at a high temperature. The value of all such salts as manure depends on the same rule as for organic matter, viz., the amount of actual ammonia they yield (see under).

Water of combination is a useless though unavoidable constituent of all dissolved manures, being the water chemically combined with the sulphate of lime or gypsum, formed by the action of the sulphuric acid employed in manufacture.

NITROGEN, EQUAL TO AMMONIA.—When present, we

always find this item at the foot of an analysis. It expresses, as we have seen, the actual quality of a manure in respect to the organic matter or ammoniacal salts present. We may add that 1 per cent. of ammonia is equal to about 4 per cent. of sulphate of ammonia.

As we have already had occasion to explain, when nitrate of soda is present it is included under the item alkaline salts; and its nitrogen, whose estimation requires special methods, should, if determined separately, be added to that otherwise obtained, and the whole calculated into ammonia.

MONOPHOSPHATE OF LIME, EQUAL TO TRIBASIC OR BONE PHOSPHATE MADE SOLUBLE.—This item has already been referred to as one of the primary constituents in all manures of the kind now under consideration, its unique value in the soil depending, as we are aware, on its peculiar ability to supply plants with the phosphatic food so indispensable to their development in a particularly acceptable form.

We have already mentioned monophosphate of lime or monocalcic phosphate as the product resulting from the action of sulphuric acid on the natural tricalcic or bone phosphate. The term soluble phosphate as commonly employed signifies the amount of tricalcic phosphate so decomposed, not the phosphoric acid occurring in manures as monophosphate and other soluble conditions, thus

accounting for the wording adopted in analysts' certificates. When we say 26 per cent. soluble phosphate, we therefore mean 26 per cent. of tribasic phosphate made soluble, a mode of statement often encountered in partial analyses, and not 26 per cent. of monophosphate: this latter would be about 16½ per cent., and is calculated from the former when the complete analysis is given. It is sometimes desirable to express soluble phosphate as actual phosphoric acid, especially when Continental buyers are concerned, who prefer that form of statement.

PRECIPITATED OR REVERTED PHOSPHATE is described and its formation explained elsewhere. We may regard it as occupying an intermediate position between soluble and insoluble phosphates. Although large quantities are sometimes present, in ordinary cases a determination of the amount is not made, but this can always be shown when requested.

INSOLUBLE PHOSPHATES.—As it is impossible in practice to render all the raw phosphate of lime soluble, there is always found in superphosphates and similar manures more or less insoluble phosphate or phosphate of lime in its original unchanged state. In superphosphates made from minerals this ingredient, as we have seen, possesses comparatively very little value. When bones are used, as in the foregoing recipes, the insoluble phosphate will consist of bone more or less changed by the acid

employed, and constitutes a component of considerable value. Many of the phosphatic guanos furnish superior insoluble phosphates. Also the various kinds of bone-meal, steamed bones, etc.; therefore to ascertain the form in which it occurs is a point of great importance.

SULPHATE OF LIME, also called gypsum, as we have previously explained, is abundant unavoidably in all superphosphates. A little is also sometimes added to assist in drying the manure. This property of sulphate of lime to take up water chemically is one of great value in connection with superphosphates, as it is the cause of their drying up spontaneously and assuming the powdery condition so necessary to their effective employment as manures. The burned, or rather baked gypsum, is most effective for drying purposes, absorbing about one-fourth its weight of water, with which it combines and which therefore does not evaporate like ordinary moisture. This baked gypsum is the well-known article called plaster of Paris. Gypsum often contains carbonate of lime, and is then unfit for drying purposes, as it "kills" the acid and undoes what we have accomplished by the dissolving process.

ALKALINE SALTS consist chiefly of sulphate of soda derived from common salt accidentally present in the materials employed, and sometimes added

with smaller quantities of potash from similar sources. When salts of potash are added in mixed manures, they will obviously come under this item, and have a special value. Potash is now largely employed thus, being found to produce a good effect in conjunction with phosphates. When a determination of the percentage present is required, a separate and special method of estimation must be resorted to. Nitrates, as we have already indicated, also occur under this heading.

INSOLUBLE SILICIOUS MATTERS are composed of the earthy or sandy matters naturally present more or less in all phosphates, which must therefore be considered unavoidable though useless ingredients. In adulterated or very inferior manures, however, this item will include any earthy substance which may have been added, as in the examples given under adulterated manures, and in such cases frequently forms the principal constituent.

The table of analyses found at p. 60 will illustrate the foregoing remarks, and show in about what proportions the several components mentioned occur in good samples. As persons are sometimes met with who have forgotten their decimals, and to whom this mode of stating the analysis is the most puzzling thing about it, we may remark for their benefit that the figures simply represent the proportions by weight in 100 parts, whether ounces,

pounds, or tons, and could not well be shown in any other way. For instance, 25 per cent. of soluble phosphate might be expressed by saying that the manure contains one-quarter or one-fourth part of that ingredient, and if it had 33 per cent. we might say it had about one-third; but if, as generally happens, the proportion is some irregular quantity, such as 23, 27, 30, or what not, these vulgar fractions would no longer define what is required, but the decimal parts of a 100 explain at a glance.

It may be added that for practical purposes the figures on the right-hand side of the point or dot are of comparatively small importance, except in the case of ammonia; although it is better to bear in mind, and with the latter constituent it is essential to do so, that ·50 is one-half, ·25 one-quarter, and ·75 three-quarters of one unit, or one-hundredth part. One per cent., or a hundredth part, is a considerable quantity of ammonia, hence it is important to know whether there be 1, 2, 3, or more tenths over or under the quantity bargained for, and this is what is represented by the figures on the right-hand side of the point, the one unit, or 1 per cent., being there divided again into 100 parts, as will be seen by any one after a little consideration.

Hitherto we have discussed considerations affecting fertilisers in whose preparation more or less elaborate processes of manufacture are unavoidably

involved; we now must notice certain natural products which become marketable far more readily, but from their nature they can only be procured by purchase, however employed.

Bones.

Bones have already been spoken of as a constituent of dissolved manures, we now refer to them as a direct fertiliser. They are an old favourite artificial manure, their striking effects in some cases on grass land having done much towards stimulating inquiry into the first principles of agricultural chemistry in bygone years. At present they are mainly employed by manufacturers for dissolving in conjunction with other materials for preparing such manures as we have previously referred to, although considerable quantities are still employed in their unaltered crushed state, and on certain soils afford a valuable manure when in the form of fine meal.

In natural bones the nitrogen and phosphate of lime are comparatively inert or dormant, requiring a long time before becoming available as plant food on the majority of soils. Hence, while possessing a special value of their own, for speedy effect they cannot be compared in their raw state with other manures of the same strength, that is to say, having the same proportions of nitrogen and phosphates in an active condition. All bones before use for

manurial purposes should be boiled to extract fat; previously to this treatment, however, it is better to grind them well, as the inner surfaces are thereby exposed and exhaustion rendered more complete, which is very necessary, for grease, apart from possessing a commercial value when separated, retards decomposition; thus, together with hard structure, accounting for that slow action of bones in the soil we have noted. Indian bones, now largely dealt with, are harder and contain less extraneous substances such as gristle, flesh, etc., than most other varieties; consequently, although the proportion of moisture may not be much smaller, we are able to grind them finer: they are also freer from fat, and for these reasons prove especially useful in manufacturing pure dissolved bones; indeed, without material of this character, whether Indian or otherwise, it would be almost impossible to produce that now so popular manure, damp bones and those rich in animal matter or grease being unsuitable for the purpose, although the two former attributes render them more serviceable for direct application.

COMPOSITION OF :—

	Bone Meal.	Boiled Bones.	Fish Guano.
Moisture	7·40	8·36	9·13
*Organic matter	28·64	22·14	65·20
Phosphate of lime	50·12	59·80	17·34
Carbonate of lime	12·98	8·46	6·70
Insoluble silicious matters	·86	1·24	1·63
	100·00	100·00	100·00
*Containing nitrogen ...	3·34	1·70	8·40
Equal to ammonia	4·66	2·06	10·20

The first sample is an example of good quality bone meal prepared from clean and unmodified material, nothing but fat having been removed and nothing added, the insoluble matters being about normal, any excess of earthy materials, however introduced, would become apparent here. Certain kinds of bone meal are found to contain common salt in considerable quantities, placed there for preservative purposes, and while therefore useful, we should be aware of its presence.

The second analysis illustrates a variety of bones frequently met with. Although commonly called boiled bones, a more accurate expression would be steamed bones. A similar material is known as "Degelatinised Bones." They have been submitted to the action of a special process for the purpose of preparing gelatine, and in consequence are deprived of much animal matter and necessarily nitrogen, as

we may observe; naturally, however, the percentage of phosphate is increased, while by grinding it is possible to reduce the material to an almost impalpable powder. This product, therefore, frequently proves exceedingly serviceable; nevertheless, when unaltered bone is required it cannot be allowed, and its presence in samples professedly so warrants an objection.

Our third example explains the composition of a valuable material to which we have already directed attention. Refuse fish has long been used as manure when easily procurable, but cost for carriage and its offensive nature prevented a wider employment; however, after many trials, attended not unfrequently with success so partial as to almost constitute failure, the excellent product we are considering is now in common use. This is prepared by a process of drying and grinding, and its clean powdery condition leaves nothing to be desired; indeed, for certain purposes, indicated in a former page, which consume the largest quantity, it is needlessly perfect, but for direct application answers admirably, manufacturers claiming that this fertiliser affords in many respects a good substitute for Peruvian guano; although of course it is not equally serviceable because solubility is lacking, nevertheless its constituents become available comparatively quickly, therefore, except for top-dressing and

other purposes where very rapid action is essential, it may be advantageously applied. Fish guano varies in quality with the materials used and the care exercised in preparing them, an important factor being the proportion of fleshy matter present, as this increases the percentage of nitrogen although diminishing the phosphates, which in this case are a minor consideration. An undue amount of oil, which retards availability, excessive moisture, large pieces of bone, and a superabundance of teeth are to be avoided. The analysis we give is that of a superior quality sample, the average being lower.

Peruvian Guano, etc.

Peruvian guano, although not as widely used as in times past, is still one of the standard manures, and likely to remain so for the present at least.

The original deposits on the Chincha Islands have long since been exhausted, and the inferior deposits now drawn upon are unfortunately not only generally of lower quality, but also of very uncertain composition. Thus, while Peruvian guano originally contained 16 to 18 per cent. of ammonia, and was so uniform in composition that no analysis was necessary when it was known to be genuine, the best now contains 8 to 10, the majority being lower, some only 2 to 3; hence an analysis is in all cases necessary, even of genuine samples. Greater care

is now, however, taken than was at one time customary in shipping cargoes, so that deterioration from that cause is avoided; moreover, of late supplies from deposits more closely resembling the older beds have been forthcoming.

Farmers should bear in mind that inferior samples may be quite genuine in the sense that they are offered in their natural condition, but obviously a proportionate price must be paid. Owing to imperfect appreciation of this fact, unwary purchasers have not seldom been duped by unscrupulous dealers.

The clay-like looking lumps sometimes found in Peruvian guano which some farmers apparently regard as really clay, or something akin to it, are actually the richest portion, and should be carefully preserved when putting the guano through a sieve or screen. They require chopping down by means of a shovel or spade with dry ashes or gypsum, if it can be had, as from their extreme richness in ammoniacal salts they may do injury if applied to a crop in the crude state.

The following table represents fair examples of the present composition of Peruvian guano with regard to essential items:—

Composition of Peruvian Guano.

Per cent.	1.	2.	3.	Meat Guano.
Phosphate of lime (total phosphoric acid equal to)	31·24	43·51	60·08	21·48
Nitrogen	7·13	4·32	2·60	5·96
Equal to ammonia	8·65	5·24	3·09	7·24
Potash	1·92	2·87	2·64	—

The samples having little ammonia are mostly rich in phosphates and these being readily available constitute valuable manures.

The unbounded faith in guano to the exclusion of other manures entertained by some farmers may be explained by the fact that in many cases they secure as good a crop from it now as formerly, and this leads them to think that analysis may after all be at fault. The fact is, however, that generally 8 per cent. or so of ammonia is the maximum amount desirable in any manure applied at an ordinary rate, and the larger quantity formerly used was in too many instances wasted. This circumstance has also during bygone days covered a multitude of sins in the way of adulterated samples; the farmer may have purchased a guano adulterated one-half or perhaps two-thirds, but as it still gave him a good crop if the season proved favourable, he was satisfied, and nothing said.

Dissolved Peruvian guano remains well established in the English market, and merits attention from its

high quality as a manure, the advantages it offers in the way of uniform guaranteed composition, and good marketable condition. These merits we have found fully borne out in our analyses of it, as the author explained at greater length in his official report to the manufacturers, with which most agriculturists are doubtless familiar.

The choice of high-class and other manures was never so wide as at present, and with ordinary discrimination on the part of buyers, never previously could such good value for money thus expended be obtained. The uncertain value, limited supply, and costliness of Peruvian guano supplied a stimulus to the use of high-class compound fertilisers, many of which are found to yield as much as 15 to 20 per cent. of soluble phosphates, and 7 to 12 of ammonia, according to price. High percentages of fertilising constituents are not, however, the only tests of merit in such cases,—a dry and powdery condition being also essential, while judicious selection and blending of the sources furnishing the several constituents contribute much, even in the case of comparatively low quality manures, to their effectiveness and profitable employment in the field.

Through want of sufficient knowledge amongst some classes of buyers concerning what is dear or cheap in the shape of artificial manures, not a few farmers are still to be found employing inferior or

even worthless articles at prices which, although low in amount, are far above their value, while really good manures, offering ample money's-worth, but necessarily higher in price, which nevertheless prove really cheaper, are persistently passed by—purchasers still too often failing to perceive that in all such cases the price per ton is quite secondary to the quantities of actual plant food, and its practical results, obtained for a given sum.

Other kinds of guano appear in the market from time to time, but the supplies seem to be very irregular and uncertain, consequently they do not demand any lengthened notice. Angamos guano may be described as a curiosity of rare occurrence containing sometimes over 20 per cent. of ammonia. The various kinds of phosphatic guano formerly much used are now no longer of importance: they contained 30 to 70 per cent. of phosphate of lime, more or less pure, that is, free from admixture with oxide of iron, and small quantities of organic matter, furnishing a little nitrogen, mostly under 1 per cent. The amount of the latter is important over and above its actual agricultural value, inasmuch as it shows to what extent the material is mineralised, its practical advantages being inversely proportional to mineralisation, that is to say, it will prove superior the more fully its natural condition of chemically minute subdivision is retained. Meat guano, of

which we have also given a partial analysis, consists of a by-product obtained in manufacturing meat extract; our example exhibits the composition of the more phosphatic variety, another type yielding nearly twice the amount of nitrogen with very little phosphate, the difference being mainly due to variations in the proportion of bone present. Other samples of English manufacture yield 6 to 7 of ammonia and 20 to 30 of phosphate.

Poultry Manure.

A correspondent expresses disappointment that "Poultry Manure" is not mentioned in previous editions, and who apparently regards it as a valuable asset in poultry-farming on account of the fact that it is derived from a similar source to guano.

Treating the latter point first, it must be remembered that guano is the dried and concentrated product of sea birds feeding practically exclusively on fish, and can only occur in hot and dry climates, being when of the highest quality almost unique as a perfect manure. The droppings of poultry, on the other hand, are derived in great part from farinaceous diet, and have the further drawback of a large proportion of moisture. Some "duck guano" which I analysed some years since showed 2 to 3 per cent. of ammonia, but displayed a great tendency to ferment, and was too offensive to permit of handling

commonly. Another sample of other poultry manure nearly dry was more promising, having 3 to 4 per cent. of ammonia and 5 to 6 of phosphates. It need hardly be said that the quantity of manure producible in this way is quite insignificant commercially, but at the same time is well worthy of conservation for use on the spot. Indeed, when poultry are kept in movable houses in colonies on grass or arable land (which appears to be one of the most satisfactory methods of making them profitable) the droppings are distinctly valuable as apart from residues from the food supplied, the birds destroy all kinds of insect vermin and convert them into useful manure.

Soot

Should perhaps be mentioned as one of the best known refuse ammoniacal manures. It varies widely in quality, not only from the kind of coal and mode of burning, but especially from the quantity of ash and cinders mixed with it. Ammonia is the only constituent of value, and varies from 3 to 5 per cent. The sulphites in soot sometimes have an injurious effect if it is used too freely.

Thomas' Phosphate or Basic Slag.

This is a material whose use is rapidly extending, although, comparatively speaking, only recently

SULPHATE OF AMMONIA.

This salt has here to be mentioned as a direct manure, but in passing we may remark that for all purposes it continues in large request. For obvious reasons the vastly larger proportion of sulphate of ammonia is obtained from gas liquor, which, by the way, is of no use as a fertiliser in its crude state. There are several minor sources, and of course any animal refuse can be burned in retorts and caused to yield this compound, but that we have examined prepared from bone is no better than samples derived from coal.

When pure sulphate occurs in small colourless crystals, which have a white appearance if massed together as generally seen. We must not, however, suppose that slight colour necessarily denotes inferiority, notwithstanding that such samples are somewhat less marketable; indeed, for this reason they often prove most profitable, as nearly identical quantities of ammonia, which is the sole constituent of importance present, may be procured at materially reduced cost; nevertheless, lower class specimens containing undesirable impurities are occasionally met with, rendering caution when purchasing very essential. The foreign bodies in question chiefly consist of excessive moisture, free acid, tarry matters, and mineral substances such as the sulphates of iron

and lime, while much more rarely sulphocyanates are encountered, which are extremely objectionable, as they injuriously affect vegetation. The yellow colour occasionally noticed is sometimes due to sulphide of arsenic, and is then, of course, objectionable; the blue colour frequently met with arises from Prussian blue compounds. Sulphide of iron has also been found to cause very dark colour. Fairly pure sulphate yields about 24½ per cent., approximately one-fourth its weight, of ammonia, but higher figures are quite usual; it is therefore better suited for application associated with superphosphate or dissolved bones than alone, as in the latter case too powerful an action, and consequent harm, may ensue, particularly if especial care be not observed to finely crush all lumps, because too much of a good thing is bad alike for plants and men.

Composition of Sulphate of Ammonia.

	1.	2.	3.
Moisture	1·24	·93	3·14
*Sulphate of ammonia, with traces of organic matter and other salts of ammonia ...	98·03	98·57	89·72
Mineral matter	·73	·50	7·14
	100·00	100·00	100·00
*Containing nitrogen ...	20·02	20·67	15·15
Equal to ammonia ...	24·30	25·10	18·36

many to buy it as it was only slightly discoloured. Its true value, however, was found to be only about half the sum demanded, and this was all the purchaser paid on learning the author's opinion. Thus, it is evident that unless reasonable care be observed to avoid fraud, the high price of nitrate renders material loss possible; nevertheless, as a rule samples conform satisfactorily to the recognised standard of 95 per cent. purity.

Composition of Nitrate of Soda.

	1.	2.	3.
Moisture	·64	1·62	1·46
Nitrate of Soda	96·57	94·93	34·60
Chloride of sodium	2·37	1·40	61·50
Sulphates, etc.	·42	·63	2·20
Insoluble matter	traces	1·42	·24
	100·00	100·00	100·00
Refraction	3·43	5·07	65·40

Potash Manures.

Kainite is a useful material, intended to supply potash to the soil—a substance which previously to its introduction had been of too high a value to allow much being employed in this manner. Its addition in conjunction with other manures on light lands is calculated to be of special service, and particularly for potatoes, as we remark when speaking of special manures. Kainite contains potash equal to

about 23 to 25 per cent. of sulphate of potash with salts of magnesia and soda. Muriate of potash is also imported as a concentrated source of potash, that occurring in commerce having about 80 per cent. of the pure salt. Sulphate of potash is also employed. It is of various qualities; nitrate of potash is occasionally used, but for general purposes it is too expensive.

Excreta Manures.

Although under this name these manures are no longer met with, the importance of the problem they were intended to assist in solving demands that it shall receive some, if brief, notice here. In the best of the night-soil phosphate patents the solid and liquid excreta, *without the addition of water*, were treated with acid and phosphatic materials, as in making superphosphate, the result being a manure combining the well-known fertilising properties of night-soil with those of superphosphate. Some of these products that came under the author's notice were of very fair quality.

The majority of manures obtained by precipitation in the purification of sewage are very poor, chiefly from the paucity of nitrogen, which is mostly in solution and cannot be abstracted by any known process. It is unnecessary to give the analyses of these articles, which consist generally of silicious

and organic matters with very little nitrogen or phosphate, and the materials used for precipitation. In connection with this subject we may refer to one popular error which goes far to subvert even the partial utilisation of human excreta as manure. It is that the solid excrement possesses value, while the liquid is useless; the same fallacious theory being extended to the manure produced in farmsteads. This error, founded on the general impressions conveyed by our unaided senses, is no more than natural, but none the less mischievous, and should have been long since dispelled by the teaching of science, not only on economic, but also sanitary grounds. So far from this impression being correct, the facts are that under ordinary conditions the urine contains much the greater part of the nitrogenous compounds present in the food, *but in a soluble form.* Therefore thousands of tons of valuable fertilising matter are allowed to be irrevocably lost, which might be saved if kept out of the sewers. It is difficult for persons unacquainted with chemistry properly to realise the influence of this attribute of solubility and its bearings on natural processes, or in other words, to understand that a clear and often colourless liquid can be loaded with solid matter in an invisible form. It is this which gives rise to the common delusion that urine can be of little worth compared with solid excrement of either man

or beast, and hence even when attempts are made to utilise town refuse of the kind, a grievous mistake is often made, as in the case of the French Poudrettes; while in regard to beasts, there will always be a serious deficit of nitrogen on a farm unless provision be made on the floors of stables, etc., to conserve the liquid as well as the solid excreta of horses and other animals; while, for the same reason, any well or other source of water at all within reach, the distance depending on the type of soil, will become contaminated; indeed, our experience proves that it is not an extravagant statement to say that on the majority of farmsteads the wells are more or less polluted.

Referring once more to our remarks concerning the treatment of excrementitious matters with phosphates and acid, it may still be hoped that possibly some such scheme, in reference at least to urine, may ultimately be made to pay; for the present enormous, and we may justly add appalling, waste of this comparatively concentrated source of nitrogen can only be condemned in strongest terms, for its collection is not attended with the same difficulties attaching to sewage matter, and if evaporated in closed vessels on the lines followed for gas liquor profitable results should be forthcoming.

It is true a slight difficulty occurs in drying up the residue, which has a peculiarly deliquescent or

undriable character, hence the use of an absorbent might be necessary, but from the richness of the material in nitrogen this might be employed without reducing the product below a marketable quality. It may be added that one of the best absorbents is the solid excrement dried up with the urine, hence the collection and desiccation of the two in this manner would appear to be the natural and reasonable disposal of them, although at present apparently attended with insuperable obstacles. These remarks regarding details, although perhaps rather out of place, are offered merely as hints indicating how the results might be attained; there are undoubtedly practical difficulties to be overcome, or the problem would have been solved long since, but the question is well worthy of careful and persevering experiment, both as a source of profit, as well as assisting to remove the reproach to our modern scientific advancement that appears so powerless to avert this wholesale drain of fertilising elements from the land, which should be a means of gain instead of danger and disease as at present.

Manures prepared from urine have been submitted to us for analysis and proved almost equal to guano, which is no more than reasonable, as it contains in its natural state nitrogen corresponding to about $1\frac{1}{4}$ per cent. of ammonia, while the solid dry residue obtained by its evaporation is one of the richest

nitrogenous materials known; containing, moreover, a large proportion of phosphoric acid with which part of the ammonia present is combined, thus forming one of the best possible manurial combinations. The systems sometimes adopted of employing urine as an ingredient of nitre beds cannot upon the whole be considered very satisfactory or worthy of recommendation, for by so doing the only purpose accomplished is a conversion of the nitrogen from one form into another, and as the original combinations are readily available, any recompense commensurate to the trouble incurred is not secured. At the same time any "compost" or other dry refuse capable of absorbing it will be greatly enriched thereby.

It must be distinctly understood that these suggestions anent drying, etc., do not apply to *sewage*, whose treatment by any such plan is of course wholly inadmissible, from the great dilution by water which all valuable constituents have undergone.

Inferior and Adulterated Manures.

It is necessary to remember that the small quantity of plant food present in purchased low-class fertilisers cannot be valued even proportionately with that supplied in superior articles, because the large quantity of useless matter they contain constitutes a drawback or "set-off" which reduces their worth as marketable commodities. For instance, the

very inferior rape-dust previously referred to, although not destitute of fertilising ingredients, would not be worth accepting for nothing if carriage had to be paid, and precisely similar statements apply to many refuse materials, and so-called cheap manures; yet these facts, apparently so simple, seem quite incomprehensible to many farmers, whose credulity and want of caution concerning matters of the kind are well illustrated by a remark once made to the author by a dealer, who stated that it mattered not what stuff he had for disposal so long as he received the supply by rail, as customers would readily be found; indeed, our experience is that beyond all doubt farmers lose far more money through purchasing absurdly cheap and rubbishy materials which never have possessed any merit worth mentioning, than by adulteration of good manures, this now being, comparatively speaking, but little practised; furthermore, while the latter evil is dealt with by the New Act, the difficulty of checking the former would appear decidedly greater. We are anxious to be clearly understood concerning inferior manures, for we do not say it would be possible to prove these so-called fertilisers were not in a sense worth the money charged, although really most wasteful and extravagant, but the truth is, as we have just hinted, that such articles are generally offered at a lower price than good manures can

possibly be obtained for, and it is with manures as with other goods—if we pay less than a reasonable price, we must expect to be taken in; hence in such cases there is the less sympathy for the sufferers. There are, however, other so-called manures for which high prices are charged, and are even more worthless than low-priced ones, while numbers of inferior mixtures pass muster year after year, at the current prices of good ones, but which are much below them in value and therefore yield an undue profit to their vendors, and against these it is as much the interest of respectable sellers as of buyers to protest.

Nothing could be a greater fallacy on the part of farmers than to suppose they can judge the quality of a manure as they do that of a sample of corn, by its appearance, smell, feel, etc. After a very wide experience on this subject we can unhesitatingly affirm that it is absolutely impossible for any one, whether chemist or not, to form any reliable opinion of a manure in this manner. As an impression to the contrary apparently prevails, of which unscrupulous vendors are known to take advantage, it becomes desirable to emphasise the fact that excellence in manures is certainly not indicated by a foul odour, but rather is the reverse of this notion true.

While it is thus the fact that there are many inferior and some adulterated manures in the market,

and that buyers must be on their guard against purchasing them, we should avoid accepting the absurd doctrine that manure manufacturers generally are rogues and making large fortunes out of the pockets of the farmer. A simple calculation of the cost of raw materials, the large capital required for the erection of works, and other considerations referred to on an earlier page will show that when the manures are supplied of the quality represented—and it is a buyer's own fault if they are not—the net profit obtained by the maker is by no means excessive, in fact considerably less than is expected in many other trades where large sums of money are expended.

The following examples of inferior and adulterated manures analysed by us will sufficiently illustrate this portion of our subject; they are selected from many similar cases which we frequently meet with.

	1.	2.	3.
Moisture	34·10	16·10	24·10
*Organic matter	16·22	22·36	35·26
Phosphate of lime ...	5·13	4·60	3·13
Sulphate and carbonate of lime	35·28	23·76	25·23
Insoluble silicious matters	9·27	33·18	12·28
	100·00	100·00	100 00
*Containing nitrogen ...	·82	1·02	1·60
Equal to ammonia ...	·99	1·24	1·94

In commenting upon these samples we may remark that No. 1 was sold at £2 per ton, but in reality was not worth at the utmost more than £1.

No. 2 was bought at £3 5s., but only about £1 should have been paid, because in addition to poor quality, the 33 per cent. of earthy matter constitutes a serious drawback, amounting as it does to one-third of its weight; therefore if three tons were purchased one would be nothing but useless material of this description. A similar statement applies to the 34 per cent. of water in the previous instance.

No. 3 was disposed of for £3 10s. per ton, although anything more than about 30s. would have been dear. This sample possessed a strong offensive smell, an important feature in the light of an earlier warning.

Another sample, the analysis of which is not to hand, was one of the high-priced articles mentioned previously, costing but little under Peruvian guano. It consisted chiefly of worthless alkaline salts, earthy matter, and sulphate of iron, with traces only of phosphates and ammonia. In this case payment for more than its value, as shown by the author's analysis, was refused; the sellers thereupon threatening an action-at-law for the balance, which they withdrew as soon as they found the buyer was not to be frightened. In cases like this a purchaser does good service by exposing such a

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slight deviations from the guaranteed quality, a result owing in no small degree to what might be described as the moral influence of wisely and constantly employed analysis; those who neglect so simple and effectual a safeguard are necessarily quite uncertain of their position. Furthermore, we can unhesitatingly affirm in districts where purchasers consistently observe such precautions, the average quality of manures and feeding stuffs supplied is, on the whole, distinctly superior to that found in other places whose residents display less forethought and wisdom, indeed, we have in this way met with some of the finest samples of linseed cake, both maker and actual buyer being unknown to us.

SECTION III.

VALUING MANURES.

ALTHOUGH not approving of the practice of chemists attaching their valuation to analyses unsolicited—never doing so ourselves unless specially requested, and subject to conditions stated on a future page—since analysts, however able, cannot be considered the best judges of commercial questions of this kind, yet it is at times unavoidable and necessary for them to ascribe a money value to the samples they analyse, and moreover very desirable for all parties that in such cases the valuation should be just and reasonable. As buyers and sellers also frequently desire to have some means of ascertaining approximately for themselves the relative values of two or more samples of which they have the analyses, the author prepared a scale of prices for the principal constituents of manures some years since, which became widely adopted, but circumstances having greatly changed, complete recasting of the information and instructions formerly given is essential. Any scale of the kind must necessarily be more

useful for comparative purposes than for arriving at the actual commercial value of a sample, consequently strict accuracy is not needed or intended, because it would obviously be impossible to devise any scale which would give correct results under all conditions, since to begin with we should want a separate price for every source of the primary ingredients, and would then still have to meet the difficulty of finding out in compound manures how much came from one source and how much from another—points on which the ordinary results of analysis throw no light. Nevertheless, the sources of the plant food furnished by a manure have much to do with its practical efficiency, especially in the case of the most costly item, ammonia or nitrogen, which may, of course, exist in forms not only useless, but positively injurious. Furthermore, this highly important consideration is much complicated by the fact that any one element not unfrequently occurs in several shapes. These points can manifestly only be ascertained by a chemist sufficiently experienced in such matters on making the analysis, and he can only say in cases of the kind what he considers a fair value for the sample. In the great majority of instances, however, any one can obtain a good general idea, sufficient for the comparative and approximate purposes already mentioned, of the money value of a sample from its analysis and

inspection, by following our instructions, which are based on a careful consideration and comparison of the composition and prices of satisfactory samples in the market. To employ such a table of values as that we give with greater accuracy is difficult for any one not a professional chemist, and he, before venturing to express an opinion, should be fully acquainted with all the circumstances of any particular transaction, because, as we shall have occasion to see, the qualifying factors are numerous and influential.

After due investigation it is thought best to adopt three prices for soluble phosphate, as it occurs in the form of mineral superphosphate, dissolved bone compound, or pure dissolved bone, respectively, even when that of the second may be derived in part from a mineral source. From the greater difficulty and cost of dealing with bones and getting them into a saleable condition, after dissolving, which is augmented in proportion as higher qualities are attained, the above course is not only justifiable, but unavoidable, to prevent ourselves erring on one side or the other, since the price at which ordinary soluble phosphate from minerals can be produced would be obviously unremunerative for the better class of bone manures. Some persons perhaps imagine it ought to be made at the same price, but this is a point which may now be considered as

settled by the laws of supply and demand. If buyers want a really good dissolved bone compound, or pure dissolved bone, they must pay the market price for it, which is certainly the lowest at which it can be made, since there is no lack of competition in the trade. When desiring to define the commercial worth of manures a scale of unit values is employed, an example of which appears later together with an explanation concerning the method of application. First, however, we may describe the procedure by which such figures for raw materials are obtained, at the same time emphasising that to attempt to do so with reference to those required for mixtures would prove distinctly misleading, because no fixed rule can be adopted, specially acquired experience and judgment being indispensable.

To ascertain the unit value of ammonia present in sulphate of ammonia, as an illustration to show the mode of working: taking the usual guaranteed quality of 24 per cent. and assuming the price to be £12 per ton, we divide the latter by the former, which gives us the result of 10s. as the unit value of ammonia from this source.

Now a very tyro must perceive that money values thus calculated cannot be available for manufactured fertilisers; in other words, merely adding together those found for the raw materials employed, supposing their certain identification possible, will not

justly estimate the market price of the whole, and a fair assessment of necessary allowance is exceedingly perplexing for the following reasons, which are by no means counterbalanced by the advantages secured through wholesale purchasing. We have to remember as important considerations: expenses incurred for working and mixing; need for reasonable interest upon large sums of money involved, a question intimately associated with the deplorable long-credit system so prevalent, extending sometimes over two or three years, and farmers have been known to consider that settling an account in twelve months amounted to cash payment; rail carriage, this of course being subject to wide variations, differences as great as from 2s. to 12s. are encountered; also allowance for unavoidable waste, etc. Bearing in mind the foregoing remarks, it is evidently almost impossible to devise a scale which shall be equally applicable and infallibly correct in all parts of the country, therefore we have striven in the subsequent table to furnish figures representing average values in most districts, excluding long credit and generally any cost for carriage, although in some more favoured localities these prices might include that item to a moderate extent. It is necessary to observe, moreover, that this scale applies to manufactured articles only, and is founded upon the present market prices.

manures may be considered to fairly represent samples of the kind, but many will be found yielding superior results, and some inferior, although similar in market prices, for practically it is most convenient to state a fixed sum without regard to small variations when within given limits.

At the foregoing prices for phosphates, ammonia, and potash, the gypsum, organic matter, etc., may be left out of account, although they possess a small, but sometimes useful value.

When comparing figures obtained by this method we must bear in mind that a price on which the buyer has to pay carriage cannot be compared with one in which this item is included; or if the buyer does not pay for a twelvemonth, or longer, after delivery, he cannot compare his prices with those for ready-money, still less for prepayment.

Again, the physical character or "condition" of manures must not be lost sight of in estimating their money value. Those in which this matter is specially attended to, and good condition fully merits expenditure of time and money to procure, are obviously worth more than those in which it is neglected, or even comparatively so. As a variety of circumstances also affect the prices in particular districts, it will doubtless be found that our scale will give values a little over the market price in some neighbourhoods, and under in others.

Furthermore, the proportion of reverted or precipitated phosphate constitutes a factor which may sometimes influence the value of manures.

This in freshly-prepared fertilisers is comparatively trifling, but in longer-made samples, such as dissolved bone manures as they unavoidably occur in commerce, it is often a matter of importance, especially with the better qualities, which are particularly liable to conversion of their soluble phosphate into precipitated phosphate through the influence of animal matter, undissolved bone, etc., an action quite unpreventable by any known means. Hence a sample which has been kept for some months, and is almost as good as when freshly made and found to analyse up to the desired standard, may, if now analysed and valued without regard to the soluble phosphate so reduced, be estimated at a price inadequate to its value.

Mineral superphosphates are less liable to deterioration from this cause, as by a judicious selection of raw materials it can to a great extent be avoided. This explains why iron and alumina compounds are such very objectionable constituents in raw mineral phosphates, for they are particularly active in producing these undesirable changes, undissolved phosphate being another cause, consequently whenever mineral ingredients are employed

it is especially necessary to exclude these injurious conditions if we would ensure a maintenance of the original percentage of soluble phosphate.

The identification of this reduced phosphate being thus often a matter of moment, we determine its amount when requested; at the same time we would plainly state that it must be considered quite distinct from soluble phosphate, and when a definite percentage of the latter is bargained for, the former cannot of course be included unless the contract is to that effect.

When first published some years since, the essential points of the foregoing remarks met with an extremely gratifying reception from both buyers and sellers, being also strongly approved by the Press, as supplying very satisfactorily a want often felt. The difficulty had always been to fix a price for soluble phosphates sufficiently high to give a fair value for the more complex manures, while not too high for dissolved mineral phosphates merely. This difficulty appears insurmountable, except by the expedient adopted of graduated prices for it as the table of unit values shows, a system which, so far as the author is aware, had not been employed before he introduced it. We should add that, except in the case of constituents in well-marked and easily distinguished conditions, it is not desirable to admit the principle of different prices for various sources

of the same fertilising ingredient, as it would be likely to lead to endless confusion.

With reference to the complaints sometimes made by manufacturers against the unjust valuation of their manures by chemists, there is occasionally no doubt reasonable ground for protest, as apparently sufficient care is not always observed with reference to certain practical details of manufacture which constitute items of cost to the maker, and consequently values may be fixed too arbitrarily. This is, of course, to be regretted, as apart from dissatisfaction caused in individual cases, the entire procedure is likely ultimately to be regarded unfavourably.

On the other hand, however, both buyers and sellers should bear in mind that considerations so numerous and complicated have frequently to be taken into account by analysts when affixing values that it sometimes becomes almost impossible to do so satisfactorily; the wide differences in money value prevailing in various parts of the country being especially perplexing.

It is true agriculturists, living in a particular district, should by this time know enough of the subject to avoid being misled, and to be able to judge of a manure from its analysis on its own merits, which some doubtless do, but there are still many farmers who understand very little about

analyses, and who rightly or wrongly look upon the chemist's valuation as the key thereto.

Consequently for this reason it is useless to say chemists ought not to give the valuation at all of samples submitted to them for analysis. Personally, in common with other authorities, we make a practice of not giving an opinion upon the value whether dear or cheap, unless the price at which the materials in question are sold is stated; under peculiar circumstances of disagreement, however, a less rigid adherence to this rule becomes desirable. In cases of this kind we accordingly supply the valuation as requested, taking as a basis the scale previously given, but also with such modifications as the sources of the constituents, condition of sample, etc., may demand. The valuations thus arrived at have, we are happy to say, been accepted in numerous cases as perfectly satisfactory to all parties. A moment's reflection will reveal that, however carefully ascertained, the monetary value of a manure by no means necessarily indicates its intrinsic worth for fertilising purposes; under certain circumstances readily soluble nitrogen, for instance, in the form of nitrate of soda or sulphate of ammonia, will give better results in the field than the more extended action due to bones, blood, etc., or again, when different conditions prevail, precisely the reverse may be true. Phosphoric acid also generally answers best in the quickly

available shape of superphosphate; sometimes, however, the prolonged influence of bones is preferable, and frequently a combination of the rapid and deferred effect is desirable, such as we secure with dissolved bone compounds, etc. In addition to, although intimately associated with, the chemical composition and physical constitution of manures we have to consider the peculiar nature and requirements of different crops, the mechanical condition, nature, and composition of the soil together with the treatment it has previously undergone; lastly, but certainly not least important, we have the influence of weather, the essential need for evenness of distribution and general skill and care required in application.

The Adulteration of Fertilisers and Feeding Stuffs Act, which came into force at the commencement of the year 1894, to which some brief allusions have already been made, does not appear greatly used by buyers of manures so far as we can learn, and judging from the author's own experience as analyst under its provisions. Doubtless, it has proved more useful indirectly by inducing sellers to conform to the regulation requiring a warranty with the goods disposed of, while obviously it is a matter of utmost importance that this guarantee should be fully verified if put to the proof; consequently, manufacturers are bestirring themselves to check their pro-

ducts more thoroughly in preparation, and to ensure that all manures sent out are quite equal to the standard of quality agreed upon.

It is only just to remark that this care and attention have long been customary amongst the best class of makers and dealers, but some others have allowed a looser system to prevail which the Act is certainly calculated to correct. Certain of our readers who might find it useful may not be aware that copies of this Act may be procured for one penny.

We should not overlook the fact that the Trades Marks Act also effected a considerable change in the manure trade, giving rise to a clearer definition of terms, and causing the introduction ot such distinctions as are expressed in the words "dissolved bone compound" and "pure dissolved bones."

Finally, it should be stated that when valuing manures, by whomsoever the work may be done, too much importance must not be attached to small differences in analysis; since the chemist can of course only judge from the sample submitted to him, and, as well known by those who have had experience in the matter, great care and some special knowledge are requisite to divide samples properly, from the neglect of which a good manure may possibly be brought into discredit. When two or more

manures are sampled at one time too much pains cannot be observed to avoid getting them confused as to numbers or marks.

A word concerning sampling manures may perhaps not be out of place here, for though the matter is now pretty well understood by buyers and sellers accustomed to deal by analysis, it is often strange to farmers. The following directions, therefore, cannot be too widely known.

In taking samples of manure, etc., several portions should be drawn from different parts of the bulk, or from separate bags, all lumps chopped down with a table-knife, and the whole thoroughly mixed, on a clean sheet of paper. Smaller portions should then be collected from this in the same manner, until a manageable quantity is obtained, of which 2 oz. to 4 oz. is amply sufficient to send for analysis if properly taken from the bulk, and it should be remembered that a larger quantity does not dispense with care in this particular. Large samples sent to purchasers for inspection may be divided in the same manner. It is almost needless to remark that in ordinary cases the Parcel Post now affords the greatest facilities for transmitting samples, the cost being small and time saved, as packets thus forwarded arrive soon after the letters of advice, which ought, however, always be posted separately. Tin or wooden sample boxes should be sent, or bottles if

carefully packed are better. Cakes should be broken across, and a strip from the centre weighing about 1 or 2 lb. sent to the chemist.

All packets need to be marked on the outside to allow of identification.

SECTION IV.

USING MANURES.

THE commonly received rule of employing nitrogenous or ammoniacal manures for cereals, and phosphatic manures for roots and green crops, is, of course, like many others, only broadly applicable, since it is now recognised that a free use of available phosphates as well as nitrogen is the best treatment for the former, while a judicious addition of nitrogen to the soluble and other phosphates applied to roots is found to be the most profitable procedure. Hence all that this rule amounts to is that we may use more nitrogen and less phosphates for cereals, and more phosphates and less nitrogen for roots. Thus a dissolved bone compound containing nitrogen equal to $1\frac{1}{2}$ to $1\frac{3}{4}$ per cent. of ammonia constitutes the most effective manure for roots, but corn crops would require far more nitrogen, which can of course be readily added; when superphosphate is made use of for turnips, etc., a more than usually liberal dressing of farmyard manure will prove advisable, a generous allowance of this latter material being generally essential if satisfactory yields are to be forthcoming.

providing themselves with the requisite manure. As previously mentioned, a considerable use of phosphates in conjunction with nitrogen for corn crops on such soils is found distinctly beneficial; under these circumstances we should advise an admixture of superphosphate with nitrate of soda whenever the latter is used upon cereals, and as it may be employed in substitution for a part, there would necessarily be some saving of cost as well as better practical results. Nitrate of soda has become very extensively employed during recent years in consequence of its comparatively moderate price; but we should always remember that applied alone it constitutes a stimulant merely, supplying nothing to the crop but rapidly available nitrogen, as already explained. We should also bear in mind that if not assimilated by the crop to which it is applied, little if any is likely to remain for subsequent crops, an advantage possessed by many other manures. This is because the nitrate is extremely soluble, and moreover soil possesses no power of absorbing it, therefore it is readily washed away by rain into the drainage, a fact already noticed. It may be added that this leads to a constant waste of nitrogen supplied from other sources, which are continually undergoing conversion into nitrates through the action of soil organisms. While any description of the process here involved would hardly be appre-

priate in a book of this kind, its importance and magnitude may be realised to some extent if we recollect that plants acquire nearly all their nitrogen in this form, ammonia, salts and organic matter undergoing the transformation more or less speedily; the loss referred to is particularly active on "hungry" soils, which derive little benefit from manure applied. For the same reason it is a mistake to put nitrates in corn manures required for autumn sowing—although a small dressing of dissolved bones at this time, when nitrate is intended to be used in the spring, has an excellent effect. In preparing the mixture of nitrate and superphosphate formerly alluded to, which must of course be in dry condition and mixed shortly before application, we should recommend $\frac{1}{5}$th to $\frac{1}{4}$th superphosphate to $\frac{4}{5}$ths to $\frac{3}{4}$ths nitrate, using the mixture at the same rate as nitrate is usually employed alone: there is no objection to adding salt as well if preferred. It may be advantageous to repeat that nitrate and superphosphate may be mixed without injury if the latter is moderately dry and without much free acid; otherwise a little gypsum or fine ashes must first be mixed with it, or there is a possibility of loss through decomposition of the nitrate. Many special manures in the market contain nitrate as well as soluble phosphate, giving, by the way, much additional trouble to the analyst, for the reason mentioned on a former page.

Clay soils differ widely in natural resources regarding the proportion of fertilising elements they are capable of yielding, and consequently as to the course of treatment that should be pursued for their profitable management. This is one of those problems which can be solved by analysis; and numerous cases have come before us of substantial benefit being derived from an analysis or partial analysis of soils.

When dealing with sandy soils, on the other hand, we encounter, as we have said, defects arising from extreme porosity, or, in other words, an absence of retentiveness consequent on the paucity or absence of clay and organic matter, which are the chief storehouses, not only of the soil's moisture, but also of plant food, either artificially added, or occurring naturally, from which the roots of the plants draw their supplies as required. An addition of clay in such cases, where practicable, is of great service, care being taken to ensure as far as possible its even distribution by drying and pulverising, otherwise it remains in clods long after application. Again the retentiveness of these soils may be enhanced by green manuring, which is an excellent resource in many such cases, and deserves to be more extensively adopted, as we can thereby obtain a clear gain of nitrogen from natural sources, and at the same time gather up and preserve any nitrates present in

the soil in a staple and efficient form ; while the humous compounds arising from the decay of the vegetable matter whose production constitutes the main advantage of this plan over feeding off a crop, afford an absorbent for moisture, etc.; hence we observe that in soils of both orders, whether too dense or too porous, an increase of organic matter is a great assistance, lightening one and consolidating the other. Phosphates, and nitrogen also if required, supplied to crops grown for the purpose are well expended, since they are returned and conserved for future use in the soil in a shape highly favourable for the nutrition of following crops. Where it is not practicable, or thought advisable to devote the whole of a crop to manure, we may adopt the principle to some extent by leaving as much as can possibly be spared for ploughing in. That vegetable matter in a readily decomposable state is a valuable form of manure is shown by the character of the wheat crop following a clover lea: where the clover has been successful, the wheat, as farmers know well, generally corresponds, and *vice versâ.* It would appear that organic matter or vegetable remains in the soil are not always adequately valued from a chemical point of view, the fact being overlooked that the quantity of these ingredients present, coupled with the valuable nitrogen they contain, may be taken as a good indication of a soil's fertility. Clover is a

particularly valuable crop in this respect where it can be grown, as in consequence of its large development of root it affords as residue a substantial gain of nitrogenous organic matter to the soil, apart from its produce above ground. This valuable result is obtained chiefly because it belongs to the leguminous order of plants, which there can no longer be any doubt indirectly assimilate free atmospheric nitrogen, consequently they provide an admirable means for farmers to procure at great advantage this costly element, and their more extended growth may be confidently recommended; furthermore, in common with other deep-rooted crops, red clover derives and renders available material quantities of plant food from the subsoil, as in addition to its peculiar attributes leguminous vegetation acquires nourishment through means similar to those employed by other groups.

The leaves and refuse of all green crops not consumed as food should be carefully returned to the land, as they furnish manurial elements in the best possible state for future use when prepared by decay in the soil. The ingredients ought, however, to be evenly distributed over the field before ploughing in; the neglect of this precaution is often evident with a crop of corn following roots, in which regular patches mark the spots where the leaves, etc., have been thrown when preparing the roots for

stock, bestowing on such places an excess of nitrogen and other constituents at the expense of the crop generally. We may take it as a general maxim not to burn any refuse, except foul turf infested with insects, or seeding weeds, that will rot in the soil, since by so doing we lose the nitrogen and all other advantages of organic matter, besides rendering the ash constituents less available.

Lest the foregoing remarks respecting green manuring should be thought at variance with the principle that we ought never to use as manure what can first be employed for food, it may be stated that under exceptional circumstances, as in the case of the light sandy soils we are considering, vegetable produce may be more valuable as manure than as food, by conducing to the physical improvement of the soil, and consequently to a higher degree of fertility. When ordinary conditions prevail it is of course only wise to feed live stock with the fodder produced; thus the excellent system of catch-cropping not only prevents waste of fertilising elements, but if properly preserved, yields excellent supplies of succulent food when much needed, while the manure obtained, together with the residues, become available for providing nutriment to succeeding crops.

For sandy soils nitrates are not well adapted, on account of their ready removal by rain in the manner

already noticed. Ammoniacal salts also should be only sparingly employed, the best form of nitrogen in cases of this kind being nitrogenous organic matter, especially as it occurs in a well-made pure dissolved bone or dissolved bone compound—indeed, for such soils no better fertilisers than these could be desired; should nitrate or sulphate be considered advisable, however, small and frequent applications made as the crops are able to assimilate them will answer best. Crushed bones alone are often employed with advantage, but the former we consider are preferable, those with a higher proportion of bone than for ordinary use being most suitable. Rape dust constitutes a good source of nitrogen under these circumstances; also dried fish or other animal matter containing nitrogen in a form not easily wasted through the non-retentiveness of the soil. Soils of this kind are also frequently deficient in lime; when this is so a dressing should be applied. The disease known as "finger and toe" often indicates a deficiency of lime.

For moderately light soils a mixture ot equal parts of rape dust or damaged cotton cake, superphosphate, and fish guano is an excellent corn manure: or for spring use nitrate of soda may be substituted for the fish.

A partial soil analysis is often valuable and can be obtained at comparatively small cost. The

following complete ordinary analysis of a strong clay soil is selected as offording a good example of the kind. The subsequent remarks have been extracted from a report made by the author upon this and several similar specimens sent for analysis from the West Indies, and although necessarily referring directly to colonial crops, they substantially apply to soils of the same character in this country. We insert the peaty soil mainly for purposes of comparison.

Composition of a Strong Clay Soil, Peaty Soil, and Turfy Soil.

(The first and second samples were taken *air dry*, the third *dry*.)

	Clay Soil.	Peaty Soil.	Turfy Soil.
Moisture	1·24	4·17	—
*Organic matter and water of combination	5·13	71·32	19·62
Oxide of iron and alumina,	10·32	4·43	9·28
with phosphoric acid equal to phosphate of lime ...	·12 ...	·04 ...	·22 ...
Lime	traces	6·70	·17
Sulphuric acid	·25	traces	—
Magnesia	·36	·34	1·04
Potash	·40	·26	·32
Soda	traces	·12	traces
Silica and insoluble silicates	82·30	12·66	69·57
	100·00	100·00	100·00
*Containing nitrogen ...	—	—	·52
Equal to ammonia... ...	—	—	·63

"The great defect in these soils generally (note the remarks preceding this table) is a too adhesive character consequent on a superabundance of clay and a deficiency of lime. The proportion of this latter ingredient in the best is smaller than should be present in really fertile land, while in the majority it is unusually low, and in many cases so little as to be inappreciable to the most delicate chemical balance. Its addition in all these cases would therefore be desirable, and this may be done by the use of any kind of calcareous material that can most readily be obtained, such as shell sand, limestone rock, coral rock, marl, etc., all of which contain lime in the form of carbonate. These substances would also have a further beneficial effect by increasing porosity; shell sand especially, freely applied, being likely to exercise a marked influence through mechanical action.

"If none of the above calcareous materials can be advantageously obtained, the use of quick or caustic lime (as used for building purposes) may be advised. This should be placed on the land in heaps and allowed to slake spontaneously, that is, become hydrated by absorbing water from the air, when it falls into fine powder, in which condition it can be evenly distributed over the surface. When using lime in this manner, one precaution must be particularly observed, that is, to allow sufficient time to

elapse between its application and that of any ammoniacal manures, since, if this be disregarded, much of these valuable compounds may be lost, lime having the property of decomposing all salts of ammonia; at least six months' interval should be allowed. I may add, that the sample of peaty soil, if procurable in quantity, is well suited to be used as a source of lime, either in its natural state or burned; in the former condition its organic matter would also materially benefit many of these soils in which this constituent is wanting.

"It must also be borne in mind that in cases of soils of this character the mechanical cultivation is as important, or more so, than the application of manure.

"In crude undeveloped soils much working in this manner is necessary to make them remunerative at all, while to attain a high degree of fertility, a constant and costly process of tillage is requisite. Judging from the samples now reported on, I should conceive that the use of steam cultivation would be found admirably suited for this purpose, if the nature of the ground would at all admit of it. I mention this, because the full remunerative effect of the manures recommended is not likely to be obtained, unless supplemented by a proper condition of the soil."

Between the extremes of strong clays and light

sands, every variety of soil is of course met with, for whose treatment no special remarks are here necessary, except that, besides the general character of a soil as revealed by its known and evident agricultural capabilities, the more intimate knowledge of its nature to be obtained by chemical analysis is often of much service, particularly in ascertaining whether it needs liming or not.

While dealing with this point we may explain that since the time the samples previously mentioned were analysed it has become customary to determine the percentage of nitrogen in soils, and as the question is one of great importance, we have inserted an example on page 125 showing that constituent. This soil proved to be greatly in want of lime, as reference to the figures will show, a dressing of which, in addition to other advantages, would have accelerated decomposition of the somewhat large quantity of organic matter, and thus have rendered the inert, although decidedly abundant, nitrogen available.

It may be well to remark the numerous references we have made to lime touch upon a matter of considerable moment, for no soil, whatever be its physical character, is capable of satisfactory cultivation it deficient in this ingredient, which, apart from its ameliorating influence in improving the soil generally, is directly required as a mineral plant food

in comparatively large quantity by all cultivated crops. Moreover, the basic properties it possesses, *i.e.*, power of combining with acids, is of the utmost value, being intimately associated with the nitrification process, the retention of plant food and other functions essential in a fertile soil, all leading to its gradual diminution; therefore, in all cases where investigation indicates an insufficiency, the addition of this compound, as we can now easily understand, exercises a most beneficial effect, and we may thus secure at small cost an improvement which more expensive manures have failed to realise, for the reason that perhaps this one essential alone was needed to develop the full capabilities of the soil. Even on lime soils, or those in which carbonate of lime predominates, the application of lime in some other shape is often of service; for instance, sulphate of lime or gypsum to clover: in this case the sulphur present is doubtless the effective agent. Gypsum, being an inexpensive material, might be freely tried upon clover layers when failing, or still better a mixture of gypsum and kainite, say two parts of the former to one of the latter, used at the rate of 4 to 5 cwt. per acre. In cases of "clover sickness," etc., this treatment is often of service, although not to be depended on as a cure; there is in fact no procedure which can be considered a remedy for it, except devoting the soil to other purposes for a number of

years, these crops being particularly insensible, so to speak, to all artificial manures. It is a well-known and curious fact that clover will not yield a good crop when repeated at short intervals, but requires the land to "rest" from it before it can be successfully repeated—no manure having been yet discovered that will dispense with this interval of time. Apparently certain peculiar conditions are requisite for its growth, which demand a considerable period for their development. The practice adopted in some districts, of applying the farmyard manure to the clover crop, often has an excellent effect.

Special Manures for Various Crops.

Regarding the further admixture referred to in an earlier page of various fertilising materials in the preparation of special manures, that is, those intended for particular crops or kinds of crops, the following recipes, in addition to suggestions already given, are offered, either to farmers who desire to attempt the preparation of their own manures, or to those who manufacture on the larger scale for sale.

On the smaller scale, the operation of mixing such substances is best performed by turning them out ot their bags on a clean surface, a boarded or asphalt floor answering well, in a flattened heap, the different ingredients forming successive layers, and afterwards putting the whole through a screen, cutting the mass

vertically with the shovel. This screening may have to be repeated to obtain sufficiently complete intermixture of the whole mass, for upon this condition much of the resulting manure's efficacy depends; during the process all lumps are broken down with the back of the shovel. The "disintegrator," as already explained, is used for this purpose on a larger scale, but even that machine, although it thoroughly incorporates the portion it contains at one time, makes no provision for the due apportionment of the components throughout the entire bulk, to secure which much care is needed, while to its neglect the disappointment sometimes experienced in the composition and action of the completed mixture is generally attributable.

Corn Manures.—Mixtures suitable for strong clay lands are given a page or so back. One of the most concentrated manures for corn crops is prepared by mixing sulphate of ammonia and superphosphate in equal parts; these ingredients, if thoroughly mingled and carefully applied, will be found to yield excellent results. Such a mixture will necessarily be expensive, and if we desire to spend less money it is easily diluted by adding an equal weight of ashes, which, should the farmer wish, can be carried still further by again diluting this second mixture with its own weight of ashes, thus obtaining a material only one-quarter the original strength, and even then this is

much superior to the low-priced manures previously described, while the cost for extra carriage, cartage, bags, etc., is of course saved. Admixture with a diluent obviously means that less of the constituents first mentioned is employed; we should, however, apply as much as we can afford, subject to another rule which will be found a most useful one for guidance in the case of manures generally. It is to treat our land with dressings of a magnitude we can reasonably expect the crops to respond to satisfactorily. When using the foregoing mixture for lighter land less ammonia may be added, one-third sulphate and two-thirds superphosphate being recommended. For spring use we might replace half the sulphate with nitrate of soda.

In the case of barley we should advise the addition of a small quantity of kainite when light soils are concerned, together with some common salt, 1 cwt. of each to 18 cwt. of the preceding mixture, whose sulphate has been partly replaced by nitrate.

Grass Manures.—For permanent grass land on strong soils, when the chief object of the cultivator is to secure satisfactory hay crops, manures providing phosphoric acid, potash, and lime, are as a rule necessary, and, grass being a member of the same family as the cereals, readily available nitrogen produces luxuriant growth. We must not forget, however, that in such pastures ths clovers form a very

important constituent, and for these an excess of concentrated nitrogenous manures is distinctly prejudicial, while the potash and lime mentioned encourage them. There can be no doubt that the plan we have so frequently recommended of feeding stock supplied with rich food procured from external sources, cake, etc., is amongst the best methods for maintaining the condition and fertility of grass land, but although too much quick-acting nitrogen must be avoided for the reason already stated, and because this procedure causes a development of coarse vegetation, light dressings of nitrate of soda and superphosphate or basic slag may be employed with advantage, abundant crops following; 2 parts of the first to 1 part of the latter would be suitable proportions, the mixture being applied at the rate of 2 to 3 cwt. per acre. On lighter grass land where bones are used we should prefer those known as vitriolised rather than the raw material; it will be well to mention that the effect produced by stock supplied with concentrated nourishment proves particularly valuable on soils of this class. Basic slag is considered especially useful upon land inclined to be sour, or slaked lime might be tried in small dressings of 3 to 4 cwt. per acre. Common salt is always useful for grass, and gypsum will give valuable results. Compost also affords an admirable manure for this purpose, assuming any reasonable amount

of fertilising material is present, because very often it consists of mere earth and worthless rubbish; properly prepared and treated with a good supply of animal and vegetable matter, nitrates will be formed and the product prove thoroughly serviceable.

ROOT MANURES.—Turnips and swedes like other root crops consume large quantities of plant food, but on good soils, with farmyard manure, or sometimes even without, mineral superphosphate is often sufficient to give a good yield, these crops standing in special need of liberal allowances of readily available phosphoric acid. On poorer soils, or when less dung is available, or superior crops desired, a good dissolved bone or dissolved bone compound is more suitable, and the extra cost will, if the season is at all favourable, give an ample return. Turnip manures are often made with mineral superphosphate and fine bone dust, and these will succeed well on certain soils, but as a rule a manure in which tbe bone has undergone the action of acid, even though not dissolved, is to be preferred. Some bone meals and steamed bones, however, form admirable ingredients for root mixtures. In such cases $\frac{1}{4}$ fine bone or meal might be added to $\frac{3}{4}$ mineral superphosphates; a recipe for turnip manure also appears on page 48. Nitrogen unless accompanied by phosphates is of little use for turnips, and then an excess

tends to an overproduction of top, hence care must be exercised in its application, but by using such sources of the element as we have indicated any risk of undesirable results becomes entirely minimised.

MANGELS are a very exhausting crop, and must be provided for accordingly, full supplies of nitrogen, phosphoric acid and potash being essential; when farmyard manure is employed, crops requiring the last-named material generally obtain sufficient; otherwise, if not present in the soil in adequate quantity, it must be provided artificially. The following mixture will be found an excellent manure for mangels: Dissolved bones 3 parts, sulphate of ammonia ½ a part, and common salt ½ a part. It should be used at the rate of 4 to 7 cwt. per acre, according to the weight of crop the soil may be expected to produce.

POTATOES also require liberal treatment with regard to manure; a suitable mixture may be prepared from 3 parts dissolved bones, ½ part kainite, ¼ part sulphate of ammonia. Kainite supplies the potash largely needed by this crop, and is sometimes recommended as a specific against potato blight; but without going so far as this, it may be accepted as a fact that this crop is particularly benefited by potash manures, and rendered less liable to disease. A noteworthy point is that while requiring ample

provision of nitrogen to yield well, potatoes receiving too large a quantity become specially subject to attacks of disease. It is impossible to do more than mention the decidedly hopeful results obtained by the lime and sulphate of copper treatment.

As a manure for forage crops and general purposes nothing better can be recommended than good dissolved bone compound strengthened with a little sulphate of ammonia, and, if intended for application on light soil, a small quantity of kainite.

GARDEN MANURES.—The use of artificial fertilisers for this purpose has, during recent years, been greatly developed for the production of vegetables, fruit and flowers, the number of such manures now on the market being considerable, which possess more or less, although necessarily varying, merit. Judiciously employed they afford valuable auxiliaries to the ordinary resources at horticulturists' command, and we should recommend as suitable, mixtures of the following ingredients:—

A manure for general garden purposes or for use by market gardeners and allotment holders may be composed of:—

Good dissolved bone compound whose undissolved bone is well softened and friable	15 parts
Sulphate of ammonia	2 ,,
Kainite	1 ,,
Gypsum	1 ,,
Common salt...	1 ,,
	20 parts

A cheaper mixture for similar purposes :—

Mineral superphosphate	15 parts
Fine bone meal	1 ,,
Nitrate of soda	2 ,,
Gypsum	2 ,,
	20 parts

A choicer fertiliser intended for potted plants and greenhouse use is thus prepared :—

Dissolved bone compound or pure dissolved bone, very dry, and containing no free acid	10 parts
Best white sulphate of ammonia...	5 ,,
Nitrate of soda	2 ,,
Muriate of potash	1 ,,
Gypsum	2 ,,
	20 parts

As these manures are dealt with in comparatively small quantities, being sold in hundredweights or even pounds instead of tons, their "condition" can be better attended to and more perfect intermixture of their components assured than is possible with those prepared for ordinary field application. To secure these desirable objects we proceed thus :

having weighed out the various ingredients, they, with the exception of the bone manure or superphosphate, which we attend to later, should be well blended, sifted, and all lumps carefully beaten down; this accomplished, the bone manure or superphosphate is now more lightly mixed with them, as by this procedure we prevent the mixture getting pasty, which otherwise it is apt to do.

When applying these manures it is well to bear in mind that they should be used sparingly, especially when potted plants are concerned, for very frequently the great mistake is made of employing them too freely.

It need hardly be said that parts in all these recipes mean equal weights, whether pounds, hundredweights or tons.

It may be added that Peruvian guano of the best quality is one of the safest manures for flowers; also very finely ground bone meal, especially samples high in animal matter, but without grease.

Although when the foregoing instructions are implicitly followed manures worthy of entire confidence for their particular purposes may be relied upon, whose preparation, moreover, is unattended by any of the risks associated with dissolving, yet many special fertilisers now offered for sale furnish such excellent value for our money, being prepared on sound scientific principles, which the position of

wholesale manufacturers and their unquestionably peculiar facilities enable them to ensure, and furthermore found by careful practical trial to be well adapted to the description of crop for which they are intended, that upon the whole we are distinctly disposed to recommend judicious and discriminating purchases rather than home production, even when the process is one of mere admixture. On the other hand, we should be particularly careful in procuring such manures that they are as good as represented, because some unscrupulous dealers make most of their profit out of these, in such cases, so-called special fertilisers, many of which are special only in name, just as it is said of dishonest tea grocers, who make a few canisters do duty for a long list of teas.

Obviously, after getting our manure by whatever means, the next thing is how to apply it to best advantage, since much of the virtue of a good manure may be lost by carelessness in this respect, while, conversely, comparatively inferior manures may yield better practical results than could be expected from their composition, by proper attention to the point. A thorough dissemination of the manure throughout the soil, within range of the rootlets of plants, is the standard we must endeavour to attain, assuming the condition of the manure is such as to allow this equal distribution. The following passage from the author's *Agricultural Chemistry*,

new edition, page 332, speaking of the mechanical properties of manures, may here be quoted: "The value of these properties is discovered more particularly in the application of manures which cannot be properly carried out without them, and so important is it that the fertilising elements of manures shall be so placed in the soil as to allow them to exercise their full effect on the plants of the crop, that a good mechanical condition will often determine the practical superiority between two or more samples otherwise much alike. In fact, a manure which is chemically deficient, may, by possessing excellent qualities in this respect, actually gain a character for higher value in the field; thus showing, not that chemical properties are of secondary importance, as we might at first sight conclude, but that the physical characteristics above spoken of are a necessary adjunct to allow of their due effect on the land, and without which a manure will compare unfavourably with others in which this point is better attended to."

The best, conditioned manures generally require some little attention before application, through the tendency of dissolved phosphates and sulphate of ammonia to adhere, even by the weight due to piling the bags one upon another, whose contents are then liable to consolidation. This caking or lumping, however, needs but the least breaking down with

the back of a shovel when the bags are emptied, and should not be confounded with the crude undisintegrated lumps observable in badly made articles. The system of mixing manures when about to be used with twice to four times their bulk of sifted ashes or dry earth is a good one, and should always be adopted, if possible, whatever purpose the fertiliser is intended to fulfil.

Concerning the important point, whether it is preferable to drill manure with the seed or to broadcast and harrow in, carefully conducted experiments on a large scale appear to prove that for roots the former method is best: when a heavy dressing is applied, however, it may be preferable to drill part and sow the remainder broad-cast. For corn crops, and all ordinary purposes, the plan of sowing broadcast is generally advisable.

Strange though it may seem, there can be no question that in most cases the soluble phosphate of our manures again becomes insoluble before assimilation by plants, that is to say, it is precipitated naturally in the soil.

Evidently if soluble phosphate remained so after application, a pronounced drawback would be introduced on account of ready loss by means of the washing action of rain; under existing conditions we must consider it decidedly superior to any other form of phosphate, because it affords the means of

getting phosphoric acid chemically diffused in the soil, that is, incorporated in a much more perfect manner than is attainable by any mechanical distribution, and to this circumstance the value of superphosphate as a manure is mainly due. In other words, when we apply superphosphate to our land the soluble phosphate soaks into the adjacent soil, and while spreading over a large surface becomes precipitated, whereas if we apply insoluble phosphatic materials at once, they remain wherever we place them, and, however much they may be stirred in, a far smaller area of soil is benefited, and the roots of crops will consequently have a more limited sphere to work in.

In conclusion we would remark that a fine condition of the soil, obtained by careful cultivation and management to secure the benefit of frost, dry weather, etc., adds much to the efficiency of manures—in fact, is tantamount to an additional dressing—a relatively small amount thus utilised being more effective than a larger quantity on roughly prepared ground, where much manure gets buried under clods and is quite inaccessible to plants. By attention to these points it is quite possible to make 3 or 4 cwt. per acre do the work of 6 or 8.

Finally, farmers should always bear in mind that ultimately it is as bad policy to starve their land as their live stock; in both cases it is quite as much as

we can expect of them to make saleable produce out of raw materials; but to suppose they can do so out of nothing, or if insufficiently supplied, is almost as absurd as it would be to expect a bricklayer to make good progress with his work and at the same time keep him short of bricks; yet this is what not a few farmers seem constantly trying to accomplish. We may depend that the full benefit to be derived from either soil or live stock can only be realised when their productive power is allowed full play by a plentiful though well-chosen supply of food.

INDEX.

L

E.

F.

G.

H.

I.

O.

P.

Q.

R.

S.

T.

U.

V.

W.

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